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Contents.

	PAGE
Cupola Coke to Iron Ratios	367
The Selling of Castings—II	368
Electrically Melting Cast Iron	369
Refractory Association Visit	369
The A.F.A. Exchange Papers	369
Trade Talk	370
Company News	370
Contracts Open	370
Characteristics that Chemical Analysis Fails to Disclose in Pig-Iron and Castings	371
Spindle Work	376
The Depression in the Steel Trade	376
The Influence of Sulphur in Cast Iron	377
Electric *v.* Crucible Tool Steel	380
Use of Limestone in Acid Open-hearth Furnace	380
Institute of British Foundrymen	381
Testing Iron to Control the Properties of Castings	385
Making Templates	386
Iron and Steel Markets	388

Forthcoming Events.

OCTOBER 31.

Institution of Mechanical Engineers:—Informal meeting in London. "Engineering Novelties at the British Empire Exhibition."

Institution of Mechanical Engineers:—Ordinary meeting at Leeds. "Heat Loss in Gas Engines," Paper by Professor W. T. David, M.A., Sc.D.

NOVEMBER 1.

Institute of British Foundrymen (Birmingham Branch):—Lecture at Birmingham on "The Iron Age," by Thos. Vickers.

Institute of British Foundrymen (Lancashire Branch):—Lecture at Manchester. "Modern Pattern-making Experience," by J. A. Stephenson.

Swansea Technical College Metallurgical Society:—General meeting at Swansea. "Annealing." Paper by Capt. L. Taverner, A.R.S.M., D.I.C.

NOVEMBER 3.

Institution of Production Engineers:—General meeting in London. "Drop Forging." Paper by B. Brett.

NOVEMBER 4.

West Yorkshire Metallurgical Society:—Discussion on "The Influence of Casting Temperature on the Physical Properties of Non-Ferrous Alloys" at Huddersfield.

NOVEMBER 6.

Institute of British Foundrymen (London Branch):—Ordinary meeting in London. "Foundry Research." Paper by J. G. Pearce.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN AND THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION.

Institute of British Foundrymen.

PRESIDENT, 1924-25, R. O. Patterson, Blaydon-on-Tyne.

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Cupola Coke to Iron Ratios.

It so happens that recently a number of foundries have been devoting much attention to the coke-to-iron ratios which obtain in their cupola melting practice, and we are afraid that there is a tendency to over-emphasise the importance of the economies derived from low coke consumptions. A deeper consideration of the subject shows that such efforts may be false economy on the following grounds: Primarily, if the metal is insufficiently hot then the waster casting debit notes may assume alarming proportions, through cold shuts, short runs and bad metal. There are two steel foundries in England using the Tropenas process, one of which works with a much lower coke consumption in the cupola than the other, and teems its iron into the converter at 100 deg. C. lower temperature; but it uses much more ferro-silicon to ensure the same necessary high temperature for the resulting steel. Here the coke economy is offset by the greater quantity of ferro-silicon afterwards used. Again, there are two important railway castings manufacturers in the North of England, one using very high-priced coke and the other the cheapest. The former uses a cheaper type of metallic burden, and the latter reasonably high-class material.

Thus it is obvious that the institution of the lowest possible coke to iron ratio in a foundry is not the *alpha* and *omega* of foundry economy, and owners and general managers should hesitate in bringing pressure to bear upon their foundry managers or foremen to reduce the amounts their experience has shown to be satisfactory—always excepting, of course, where an entirely new set of conditions is to be instituted.

Whenever references to extremely low cupola coke consumptions are quoted, the following information should also be given:—(1) Whether the bed coke is included; (2) size of cupola; (3) length of run; (4) type of casting made; (5) type of coke used; (6) type of metallic burden used; (7) average temperature of metal; and (8) whether warm or cold blast is used. Unless the majority of this information is available, then the mere statement of a coke-to-iron ratio is almost worthless. However, when the full details are known, they form, when auxiliary information as to number, size and height of the tuyères, blast pressure and volume are given, an excellent basis for comparison. Such information will enable those in charge of foundries to modify their practice so as to align with the best in the land, and ensure a national economy.

Economy in coke is of paramount importance, but it is pure short-sightedness to minimise it in one process, if it involves either earlier or later further employment of combustible material or its equivalent. If a percentage of the castings are wasters then they require more coke for re-melting; if more ferro-silicon has to be used in a complimentary process, then the coke or electricity—its equivalent—which was used to produce it is wasted.

Using the indefinite, yet well understood language of the foundrymen, the essential work of the cupola is to produce good, hot, clean and fluid metal, and if a certain amount of extra coke has to be used to obtain this then it is definitely worth while.

The annual congress of the Association Technique de Fonderie is this year being held at the Conservatoire National des Arts et Metiers, 292, rue St. Martin, Paris, from November 21 to 23. British foundrymen are invited to participate.

The Selling of Castings.—II.

By Voyageur.

The first step in beginning the scientific selling of castings is to overhaul the internal organisation so as to remove from the work of selling every hampering and uneconomic form of procedure. First and foremost, the work of making sales, of planning sales campaigns, of exercising watchful supervision over travellers, advertising, agencies, branch offices, and so forth, must not be left to *anybody* to do. In many foundries, unfortunately, one director looks after agencies; another controls the salesmen; a third does the advertising in his spare time; a fourth puts an oar in every now and again, when he feels in the mood to do so. The secretary or the chief clerk and their subordinates have bits of the detail work allotted to them, irrespective of their capacity and time for the work. What is the result? Nothing is co-ordinated. Selling plans are haphazard, changed at will, split up into opposing parts; advertising is execrable; no one knows what the policy is, and, in fact, there is often no policy, because it is nobody's job to formulate one. Now in production a works manager unifies the whole of the manufacturing methods. He and his staff are collectively responsible for the carrying on of certain specific functions. No one dreams of coming along and telling him how much scrap and of what sort he must put in his next melt. But in selling, which is quite as important in its way as production, the need for unification and technical knowledge does not seem to be recognised. It is as essential that there should be a complete sales department, under the control of a sales manager, as that there should be a complete foundry under control of a foundry manager.

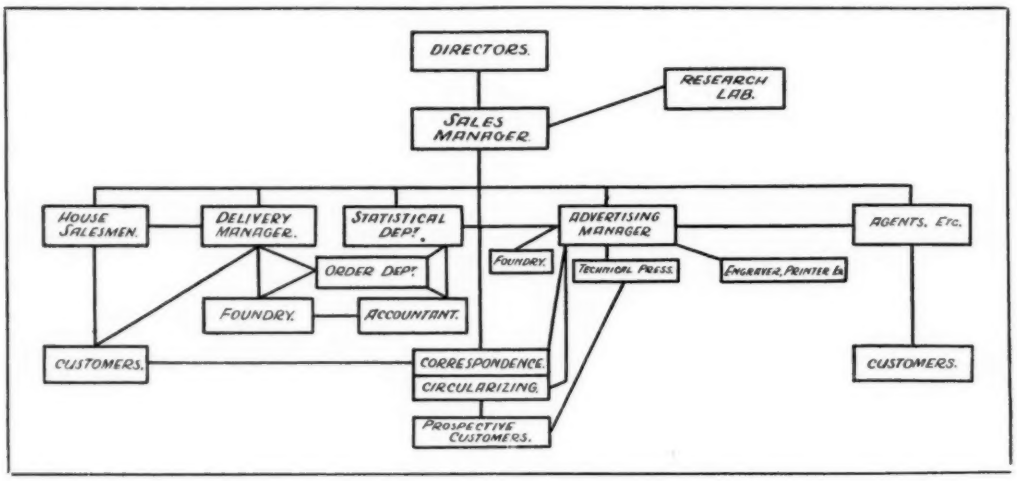


Fig. 1.—Scheme of Organisation for a Foundry Sales Department.

Scope of Sales Department.

The object of a foundry sales department is to sell castings, and to sell still more castings; to get on better terms with customers, past, present and potential; to analyse the markets; to work out and execute practical selling schemes, and advertising campaigns; to keep in close touch with salesmen, branch offices, agencies, production and research departments, and so forth. In short, to give to the arduous work of selling as complete and comprehensive an organisation as that given to the work of actual manufacture.

The Composition of a Sales Department.

The sales manager, who should supply the brains of the whole department, often has a seat on the board of directors, and it is almost essential that he should have had some experience of salesmanship "on the road." If, in addition, he combines with this some first-hand knowledge of the principles of modern publicity work, he will be doubly valuable. He must evolve a rational and definitive selling policy, and see that this policy is carried out in every branch of activity connected with selling. The directors must keep him advised of any changes in policy, so that he may modify his selling policy accordingly.

The salesmen will be under his direct supervision. He will exercise when necessary discretionary powers in connection with the advertising campaign as drawn up by the advertising manager. In fact, he is responsible to the board of directors for the maintenance and, if possible, continuous increase of the yearly sales. The sketch, Fig. 1, indicates as clearly as may be the ideal scheme of organisation for a foundry sales department.

An integral part of the sales organisation is the delivery manager, whose work is to hasten the despatch of all urgent orders, to take up complaints and remedy them, to discover the cause of delays in delivery, and, in short, to act almost as the customer's direct representative at the works. For this purpose he must be external to the production staff, so that he may tackle foundry foremen, foundry managers, machine-shop foremen, and so forth, without hesitation. He must, above all things, be tactful, patient, dignified, and restrained, yet capable of taking a strong line when circumstances demand it.

The advertising or publicity manager is in his way a specialist or technical member of the sales department. His task is to co-operate with the sales manager in the preparation of an advertising campaign in conformity with the general sales policy; to supervise the execution of this campaign from the technical point of view; to design and write advertisements; to select the best media for these; to write, design, and superintend the printing of catalogues, price-lists, and similar publicity literature; to arrange exhibition stands when necessary; to edit a house-organ, if the foundry publishes one; to order and check printing, engravings, drawings, and so forth. He must draw up tables and charts showing the results of his advertising; he must seek out new selling ideas; and, finally, he must do his best to sell castings by means of print and paper.

The statistical department is often the most necessary and most seldom found of all in the foundry world. Some foundries do devote a member or two of their staff to the work of getting out cost figures, pig-iron consumption figures, coal-consumption figures, and similar statistics; but they seldom perceive that there are other sets of figures of almost equal importance, without which selling must be an uncertain business. Strictly accurate details of the following kind are essential in scientific selling: total sales for a given year; total expenditure on advertising and publicity; total expenditure on catalogues and similar printed matter; total expenditure on circularising; comparative figures for past years; total of new accounts opened during the current year, and in previous years; total cash value of these new accounts; percentage of these, that can be definitely ascribed to advertising, to salesmen, to literature, to circularising; percentage of total output of castings sold to particular industries or groups of consumers, i.e., railways, and so on.

The sales department should have its own correspondence staff of typists, from whom greater intelligence will inevitably be demanded than from the general staff. Organised in the way outlined, it will (*i.e.*, the sales department) be ready to begin the great attack upon markets for which it exists. But before it can initiate this attack it must, like the general staff of an army, study the battle-field. In other words, it must analyse the markets thoroughly. This is a procedure that demands much time and study, and an account of how it may best be conducted will form the subject of the next article of this series.

Electrically Melting Cast Iron.

At the Detroit meeting of the American Electrochemical Society a luncheon-table discussion was held upon the problem of electrically melting cast iron. Mr. G. K. Elliott, of the Lunkenheimer Company, Cincinnati, presided.

Dr. Richard Moldenke, Watchung, N.J., opened the discussion. Starting out with the various methods of producing steel castings, Dr. Moldenke said that the crucible, the cupola and converter, and the open-hearth processes are all as expensive as electric furnace melting, and that the real question was one of investment and the tonnage desired. As to malleable castings, he said that the air-furnace and open-hearth are equally as expensive as the electric furnace, and that here also the question was one of the first cost and the tonnage desired.

In grey iron, said Dr. Moldenke, duplexing is the simplest solution for the usual foundry. Almost any work is possible when borings, turnings, steel scrap, etc., must be dealt with. Here, too, comes in the question of first cost and tonnage. Referring to Mr. Elliott as one of the pioneers in duplexing, or the use of electric furnace with the cupola on grey iron, Dr. Moldenke then discussed under three heads the particular advantage of the use of the electric furnace in the grey iron foundry. The first advantage, in his opinion, was the ability to superheat the iron. While this is also possible, in some cases, with the cupola, it is not as practicable nor quite as efficient. The second advantage, in his opinion, was the ability of the electric furnace to de-oxidise the metal, and he regarded this as possible of accomplishment only with the electric furnaces. The third advantage he enumerated was de-sulphurisation. Cast iron, high in sulphur, can be decidedly improved so far as sulphur content is concerned in the electric furnace, but the speaker called attention to the strides which have lately been made in chemical de-sulphurisation of cast iron by the use of soda ash and other similar materials added usually to the ladle. He then also described several modifications and improvements of this process, which he had observed in Germany, and stated that it was possible that this chemical operation might be a competitor of the electric furnace so far as de-sulphurisation is concerned.

Dr. Moldenke closed his remarks with the statement that the electric furnace stands first for quality, but it involves large first cost, the operating expense being fixed by the locality and other factors. Its low tonnage capacity, as compared with the cupola, should also be considered.

Mr. Elliott at this point, by showing of hands, ascertained that there were about twenty representatives of companies using electric furnaces in steel or iron foundries, and that ten of these were actually making grey iron castings in one way or another in electric furnaces.

Grey Iron Borings.

One of the most interesting subjects discussed was the melting of grey iron borings in electric furnaces for incorporation in castings. Two practices in general were cited, one the use of sprue and other scrap in conjunction with borings, and the other the addition of borings to a melted pool of some form of scrap. The practice of a company in Vancouver, B.C., was cited where commercial borings and scrap are melted on a large scale, and also the use of five furnaces for producing grey iron in certain specialty plants. Of course, it was generally conceded that the cupola is a cheaper medium where coke is at all available advantageously. The particular success of the electric furnace in iron foundries on the Pacific Coast was frequently mentioned.

An advantageous method of melting borings, whether in the cupola or in the electric furnace, was suggested by one or two speakers, which involves the mixing of carbon with the borings, particularly in the shape of briquettes. One speaker cited the experiments of the Connecticut Electric Steel Casting Company in making synthetic cast iron from steel scrap so that it could compete with pig-iron.

Synthetic Cast Iron.

The general subject of synthetic cast iron was also one of the topics. Dr. Moldenke stated that this was a tonnage proposition in Europe, and that it had been possible to produce such iron in the cupola, using petroleum coke, making a product as high as 3.10 per cent. in total carbon. Another interesting suggestion which was made by one of the speakers was a recent attempt to mix magnetic iron ore with peat in the form of briquettes, passing these through a gas-fired retort, thus converting them partly into iron sponge and using this as a raw material. The promoters of this ran out of capital, but the speaker felt that there was some value in the suggestion, as peat is very cheap and can be obtained even as a by-product in the form of fine powder.—"Iron Age" Report.

Refractories Association Visit.

The Monthly Bulletin of the Refractories Association, of which Mr. Frank Russell, F.G.S., is President, and Mr. W. J. Rees, B.Sc., F.I.C., of Sheffield University, is Secretary, contains an account of an interesting visit of the members of that Association to the works of James Oakes & Company, Alfreton, on October 3, when the party was entertained to luncheon and tea by Mr. C. H. Oakes, the sole proprietor of the firm.

Mr. Oakes, in an interesting discourse, described the origin and growth of the works, and in response to the toast of "The Refractories Association," proposed by Mr. Oakes, the President of the Association, after thanking him for his kindly reference to the work being done by the Association and his generous hospitality, congratulated him heartily on the magnificent success which had attended his efforts to develop the large-scale production of pipes, conduits, etc. The thanks of the Association were also tendered to Mr. T. Searson, the manager of the Fireclay Works, for suggesting and arranging the visit.

The A.F.A. Exchange Papers.

Mr. Wesley Lambert, the joint author with Mr. George Hall of the Paper on "Modern Bell Founding," given on behalf of the Institute of British Foundrymen to the American Foundrymen's Association, has received a cablegram reading: "Please accept and extend Hall our appreciation your excellent Paper most enthusiastically received.—American Foundrymen's Association."

MR. GEORGE SENIOR has recently been elected a director of the General Refractories Company, Limited, Sheffield.

THE LANCASHIRE METAL FLUX COMPANY, of Garden Street, Heywood, Lancs., has changed its name to the Lancashire Metal Flux Works. Mr. A. Greaves, who is the author of "The Foundryman's Educator," is now sole proprietor.

The annual dinner of the London staff of Allen Liversedge, Limited was held at the Trocadero last Friday evening, Mr. C. Storey Gilman, J.P., Chairman of the Company, presiding. Among the guests present were Sir Samuel Barrow, K.B.E., His Honour Judge Bowen, K.C., Rear Admiral E. Liversedge, R.N., Major Fawcett, and Messrs. K. S. Murray, Russell, Sinclair, Shave, and others. Toasts were limited, by special request, to those of the King (proposed by the Chairman) and the Company (proposed by Mr. K. S. Murray, managing director, the British Oxygen Company).

XUM

Trade Talk.

THE BARRONIA METALS COMPANY, LIMITED, have removed their offices to 47, Victoria Street, S.W.1.

THE BRIGHTSIDE GALVANISING COMPANY have removed to new works at Feeder Road, St. Philip's, Bristol.

CONSIDERABLE DAMAGE was done by a fire which broke out at Millbrook Foundry, Landore, Swansea, last week.

FAIRBAIRN, LAWSON, COMBE, BARBOUR, LIMITED, have decided to close down the machine-tool section of their Wellington Foundry.

A LICENCE UNDER THE Non-Ferrous Metal Industry Act, 1918, has been granted to D. A. Peebles & Son, 2, Inglefield Street, Govanhill, Glasgow.

THOS. W. WARD, LIMITED, Silvertown, London, E.16, have acquired the whole of the plant at the works of Sir John Jackson, Limited, Grays, Essex.

VICKERS, LIMITED, have offered to associate with the Broken Hill Proprietary Company with the object of manufacturing armour-plate and shells at their Newcastle Works.

THE NORTH OF IRELAND SHIPBUILDING COMPANY, LIMITED, have decided to discontinue work at Londonderry Shipyard until an improvement in the situation warrants resumption.

MR. H. A. COWLIN, the South Wales representative for Hans Renold, Limited, has transferred his office from Walliscote Road South, Weston-super-Mare, to 69, Victoria Street, Bristol.

W. E. BURNAND & COMPANY, Chippinghouse Works, Lowfields, Sheffield, have acquired the Argus Works, Shoreham Street, Sheffield, to which they will remove when structural alterations have been completed.

J. DAMPNEY & COMPANY, LIMITED, Thos. Wilson & Sons (Swalwell), Limited, and Sir James Farmer Norton & Company, Limited, have been elected members of the Federation of British Industries.

THE FURNIVAL STEEL COMPANY, of Sheffield, have just taken on lease additional premises fronting Furnival Street, Eyre Lane and Furnival Lane, for the extension of their smiths' shops and works generally.

ELTON LEVY & COMPANY, LIMITED, and Geo. Cohen, Sons & Company, Limited, have purchased from the Cape Copper Company, Limited, the copper smelting works at Briton Ferry, South Wales, which have been closed down for about four years.

THE TENDER OF Thos. W. Ward, Limited, Sheffield, for five miles of 6-in. steel lapwelded screwed and socketed piping has been accepted by Steel Bros. & Company, Limited, London, for export to the Attock Oil Company, Limited, Rawalpindi, India.

A COURSE OF SIX lectures on "Furnace Heating" will be given by Mr. R. J. Sarjant (of Hadfields, Limited), at the University of Sheffield, in connection with the Department of Fuel Technology, on successive Thursdays, commencing to-day.

THE FEDERAL ADMINISTRATION of the Austrian Railways is at the moment considering the question of future supplies of rails. It appears that the only tender received from an inland firm was that of the Alpine Montan Company, which was considerably higher than those received from German concerns. The only other plant in Austria is the rolling mills of the Southern Railway in Gratz, but this has been idle for some months.

MR. NORMAN GODFREY, chairman of Thomas Smith's Stamping Company, Limited, addressing the annual meeting of shareholders at Birmingham, declared that the removal of the McKenna duties had produced serious effects on the motor car industry. There had been a wholesale suspension of orders. This curtailment was immediately reflected in their Coventry works, where their programme was thrown into disorder when the maximum output should have been obtained.

THE DIRECTORS OF Bolckow, Vaughan & Company, Limited, in their annual report, point out that they have called up the balance of 8s. per share on the 1,860,900 ordinary shares, for the purpose of reducing the overdrafts owing to bankers. A committee of shareholders was appointed at the last annual meeting of the company, and they have from time to time met representatives of the board. A thorough reconstitution of the board and the appointment of a managing director have been discussed, and the directors are of opinion that steps in both these directions should be taken. Without prejudice to any steps which may be taken for the reconstitution of the board, the following directors retire:—Sir J. E. Johnson-Ferguson, Bart., and the Hon. Henry D. McLaren, C.B.E., who are eligible and offer themselves for re-election: Mr. Walter W. Storr also retires, but does not seek re-election. The board regrets that, owing to ill-health, Mr. Illtyd Williams, who has been a member of the board from the year 1905, has felt it necessary to tender his resignation.

Company News.

Ropner Shipbuilding Company, Limited.—Trading loss, £7,761.

British Electric Transformer Company, Limited.—Profit for half-year, £1,236.

Tondu Engineering & Wagon Company, Limited.—Capital £20,000 in £1 shares.

Babcock & Wilcox, Limited.—Interim dividend, 5 per cent., tax free, on ordinary.

Hume Pipe and Concrete Construction Company, Limited.—Debit balance, £10,452; no dividend yet paid.

Wheeler & Sons (Engineering), Limited, St. Stephen's House, Westminster, London, S.W.—Capital £100 in 1s. shares.

Coventry Chain Company, Limited.—Final dividend, 10 per cent. actual, less tax, on ordinary shares, making 15 per cent. for year.

E. Youngs & Company, Limited.—Capital £15,000 in £1 shares (7,500 ordinary and 7,500 5 per cent. cumulative preference). Engineers.

Stothert & Pitt, Limited.—Loss for year, £11,591; transferred from reserve, £9,000; amount brought forward, £2,713; carried forward, £122.

Hughes-Johnson Stampings, Limited. — Profit, £6,187; brought forward, £2,407; dividend, 7½ per cent., free of tax; carry forward, £2,294.

Welding, Son & Company (Vauxhall), Limited, 77, Vauxhall Road, Liverpool.—Capital £1,000 in £1 shares. Machinery merchants. Director: T. C. Welding.

Bretts' Stamping Company, Limited.—Net profit, £6,028; brought forward, £2,005; available, £8,033; dividend 10 per cent. on ordinary shares, less tax; general reserve, £2,000; carry forward, £2,004.

Hillingdon Screw and Manufacturing Company, Limited, Hillingdon Heath Engineering Works, West Drayton Road, Hillingdon Heath, Middlesex.—Capital £2,000 in £1 shares. Directors: O. Turner and F. Turner.

Perry Bar Metal Company, Limited, Stonehouse Works, Perry Bar, Birmingham.—Capital £5,000 in £1 shares (4,700 7½ per cent. cumulative preference and 300 ordinary). Directors: C. H. Twigg, J. S. Evenden and F. W. Lewis.

Storey Foundry Company, Limited.—Capital £2,000 in £1 shares (1,500 6 per cent. cumulative preferred ordinary and 500 deferred ordinary). Engineers and ironfounders, etc. Directors: J. E. Storey, R. Storey, W. Tait and J. O. Houldsworth.

E. M. Ling Engineering Company, Limited, 12, Grosvenor Gardens, London, S.W.1.—Capital £3,100 in 3,000 8 per cent. cumulative preference shares of £1 and 2,000 ordinary shares of 1s. each. Directors: E. M. Ling, Florence L. Rudston-Brown and P. Swan.

Aurora Gearing Company (Wilmot North), Limited, Edmund Road, Sheffield.—Capital £12,000 in £1 shares (9,700 ordinary and 2,300 non-cumulative 7½ per cent. preference). Pattern makers and general engineers. Directors: W. North (managing director), C. North and R. W. North.

Hall & Pickles, Limited, 64, Port Street, Manchester.—Capital of £260,000 in £1 shares (30,000 5 per cent. cumulative preference and 230,000 ordinary). Iron and steel merchants, metallurgists, etc. Directors: J. Hall (chairman), E. B. Hall (deputy-chairman), C. F. L. Mace and J. Ward.

Brampton Brothers, Limited.—Net profit, £22,313; brought forward, £11,221; interim dividends paid on preference and ordinary shares, £3,787; available balance, £29,747; final dividend on preference shares, 6 per cent. per annum, less tax, making 6 per cent. for year, £1,743; final dividend on ordinary shares, 7½ per cent., free of tax, making 10 per cent. for year, £6,131; reserve account, £10,000; carry forward, £11,872.

Contracts Open.

Southport, October 31.—About 90 tons of 6 in. dia. cast-iron spigot and socket pipes, for the Southport, Birkdale and West Lancashire Water Board. Mr. C. B. Ede, engineer and manager, 14, Portland Street, Southport.

Dundee, November 11.—Approximately 70 tons of 4-in. internal diameter and 90 tons of 6-in. internal diameter cast-iron pipes, with turned and bored joints, for the Dundee Water Commissioners. Mr. G. Baxter, junr., engineer and manager, 93, Commercial Street, Dundee.

Southend-on-Sea, November 5.—Approximately 150 tons of 18 in. c.i. pipes and special pipes of British manufacture, for the Corporation. Mr. R. H. Dyer, borough engineer and surveyor. (Fee, £2, returnable.)

MR. G. B. PETTER has resigned his position as resident director of Vickers-Petters, Limited, and has returned to Yeovil. He will retain his position as a member of the board.

Characteristics that Chemical Analysis Fails to Disclose in Pig-Iron and Castings.*

By W. E. Jominy, Ann Arbor, Michigan.

There has been some disagreement among foundrymen as to whether or not cast irons of the same elemental chemical composition have the same or different characteristics when produced under varying blast furnace and cupola conditions. The controversy is particularly rife when the discussion of these variations leads to the subject of coke irons as compared to charcoal irons.† It does not confine itself to these two types of irons. Many contend that different coke irons will have dissimilar characteristics even though the carbon, silicon, manganese, phosphorus, and sulphur contents may be the same.

The greatest differences of opinion, however, appear when coke and charcoal irons are considered. The considerable variations in the methods by which coke and charcoal irons are produced would certainly make the differences in characteristics much more pronounced between these two types of irons than would be expected between two different coke irons or two different charcoal irons of the same chemical composition.

Furnace Conditions Different.

It is customary to run coke furnaces with higher blast temperatures and pressures than are used with charcoal furnaces. The sulphur content in the coke requires a slag relatively higher in lime. The higher melting point of this limey slag makes it necessary to maintain a higher hearth temperature in the coke furnace than in the charcoal furnace. The latter can operate with more acid and consequently more fluid slag because of the freedom of the charcoal from sulphur.

The coke furnaces, which produced the irons dis-

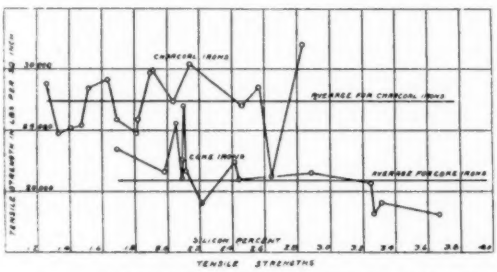


FIG. 1.—COMPARISON OF TRANSVERSE STRENGTHS OF CHARCOAL AND COKE IRONS.

cussed in this Paper, operated with an average blast temperature of 705 deg. C., and a blast pressure of 14 lbs. per sq. in.; whereas, the charcoal furnace operated with an average blast temperature of 565 deg. C., and a pressure of 4½ lbs. per sq. in. The temperature of the iron coming from the charcoal furnace averaged about 160 deg. lower than similar iron from the coke furnaces.

There is considerable evidence of a practical nature which would tend to make one believe that there is a decided difference in the properties of the two irons. Many foundrymen have found that it is less difficult to obtain good castings when using pig-iron from a charcoal blast furnace than when using pig-iron from the usual coke furnace. There is need for more scientific verification of these practical observations.

Knowledge of Pig-iron Characteristics Limited.

There are so many variables which enter into the making of good castings and poor castings that it has been difficult in the foundry to show conclusively the superiority of one iron over another. When trouble is experienced in making good castings it is very difficult to determine definitely whether the pig-iron is the cause of this trouble or whether it is any one of the host of other variables which must be dealt with in the foundry. Knowledge of the properties of pig-iron is limited to interpretation of the chemical analysis, which as will be seen from the results of the researches herein reported, certainly offers little information concerning the strength and hardness of the iron. A considerable amount of written discussion has been published on the subject. The majority of this has been based on rather meagre data.

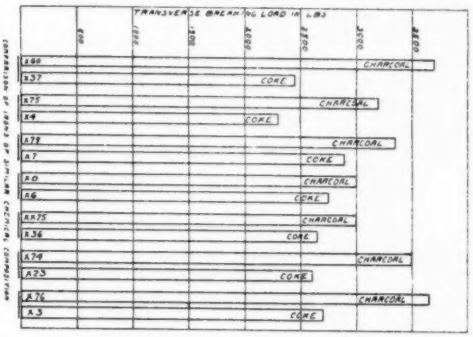


FIG. 2.—COMPARISON OF TENSILE STRENGTHS OF CHARCOAL AND COKE IRONS.

J. E. Johnson, Jr., has probably written more to the point on this subject than any other investigator. He has reached some very definite conclusions with respect to the reasons why charcoal iron is superior to coke iron. He attributes the superiority to the presence of oxygen in the former. His conclusions, however, have only been supported by data from tests which he made on eight different pieces of iron.

The author has examined approximately one hundred samples of pig-iron in the investigation recorded in this Paper, which has been submitted to contribute sufficient reliable data to show that there are large differences in irons having the same chemical analysis and that these persist through the remelting. The results support most of Johnson's contentions regarding the superiority of charcoal irons. In addition, they show the variations of irons in strength, composition, and metallographic structure when produced in blast furnaces under known widely variant conditions.

No attempt was made to verify the relation of the oxygen content of the irons to their strengths as suggested by Johnson. Johnson used the Ledebur method for the determination of the oxygen and according to the findings of Cain and

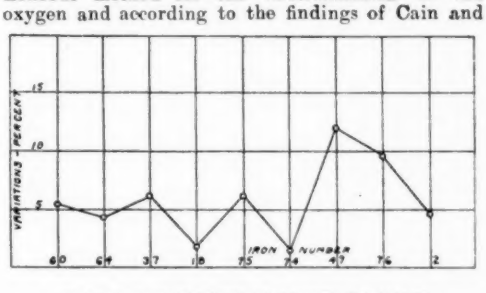


FIG. 3.—PERCENTAGE VARIATIONS OF BREAKING LOADS OF IRONS ON RE-MELTING.

Pettijohn, the Ledebur method for this determination is not strictly accurate. Since Johnson was dealing with such very small quantities of oxygen a slight inaccuracy in the method might lead to errors of considerable magnitude. For this reason and the fact that no foundry laboratory is equipped to make these determinations, it has been endeavoured to find some other characteristics or combination of characteristics by which the suitability of a pig-iron can be determined.

D

* Extracted from a Paper read before the Milwaukee meeting of the American Foundrymen's Association. The author is associated with the Department of Engineering Research University of Michigan.

† American equivalent of cold blast iron.—EDITOR.

Sampling Conditions.

The samples of pig-irons used in the tests were taken from time to time over a period of four months from five different blast furnaces. On many of the heats from which samples were taken, the writer noted the blast-furnace conditions such as temperature and pressure of blast, and analysis of the slag run from the furnace just previous to the time of pouring. This was done in an effort to correlate the properties of the irons with some of these conditions at the blast furnace, but no relation was discovered.

It was endeavoured to have the irons poured under as nearly the same conditions as was pos-

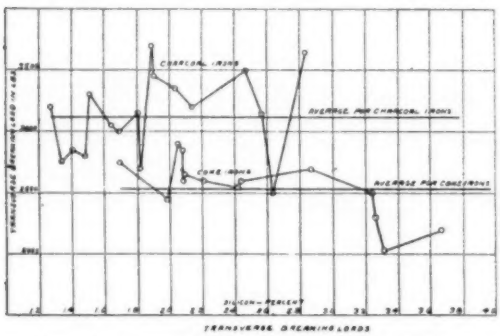


Fig. 4.—Comparisons of Irons of Similar Compositions.

sible. For this purpose, arbitration test-bar moulds, made practically in accordance with the specifications of the American Society of Testing Materials, were used. They differed slightly in that the gate was made wider than that required in the specifications. This was done because it was desired to have sufficient material for remelting without having to use the test pieces proper. The pouring was accomplished by tapping off the iron as it flowed from the blast furnace into a ladle placed about 50 ft. from the blast furnace and pouring from this ladle into the arbitration moulds. The test bars thus produced were 1¼ in. dia. by 15 in. long, and were shipped from the blast furnaces attached to the gates. There were two bars on each gate and hence of the same composition. The test bars were numbered as received in such a manner as to identify them with the heat numbers at the various furnaces from which they came. They are referred to in this report according to this number.

The only other variations from the specified procedure were that these test pieces were poured into undried moulds at the coke furnaces. Dried moulds were used at the charcoal furnace. Of necessity, the chemical compositions of the samples varied with different heats.

Tests Made.

The test bars, as received, were broken from the gate and subjected to a transverse test. Tensile

Fig. 5.—No. 60 Unetched × 100. Charcoal Pig-Iron Si; 1.98 per Cent. Transverse Strength 2,700 lbs.

test specimens were then made from the lower half of each of the transverse specimens and the standard tensile test for cast iron was made on each.

Both Brinell and Rockwell hardness tests were made on the transverse specimens near the fracture. Many of the samples were likewise subjected to a metallographic examination at and near the fracture. An attempt was made to correlate the variations in physical properties with the chemical properties. It was impossible to observe any correlation whatever. Of course, the results of those test pieces which showed blow holes or slag or carbon inclusions in the fracture were discarded.

Some Interpretations of Data.

The data were separated into the two tables and tabulated according to the silicon content for convenience of examination. All the data given for physical properties represent the average of two determinations for each iron. It will be noted that the average results for the charcoal irons are higher than those for the coke irons, even though

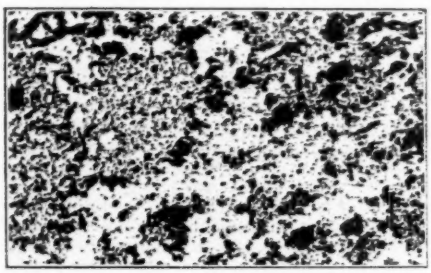


Fig. 6.—No. X 60 Unetched × 1,000. Re-melted Charcoal Iron; Si 1.90 per Cent. Transverse Strength 2,700 lbs.

there is no outstanding difference in the chemical compositions except perhaps the carbons and with these the difference is such as would normally be expected to favour the coke irons. The Brinell readings for the coke irons range from 121 to 159, whereas for the charcoal irons the limits were 134 and 171. The range of transverse strengths in pounds were for the coke irons 1,700 to 2,900, and for the charcoal irons 2,100 to 3,050. The tensile tests showed results varying from 5.5 to 10.1 tons per sq. in. for the coke irons and from 7.7 to 11.8 tons per sq. in. for the charcoal irons. When it is remembered that the moulds at the coke furnaces were of green sand, and not dried, whereas the moulds at the charcoal furnace were dried, these results have added significance. It must be remembered that the iron from the coke furnaces was poured at a relatively higher temperature, about 165 deg. Cent., in those observed by the author, than that from charcoal furnaces.

It is generally accepted that it is extremely difficult, if not impossible, to obtain satisfactory castings by pouring directly from the blast furnace into the moulds. The results are in accord with this idea, only the averages being of any consequence.

How Iron was Remelted.

Therefore, in order to prepare the samples in a manner which would more satisfactorily permit of

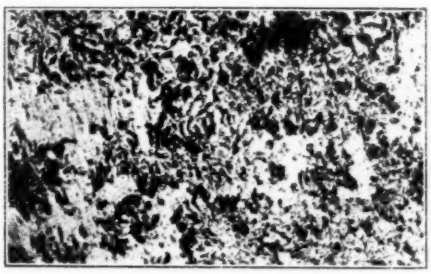


Fig. 7.—No. XX 60 Unetched × 100. Second Re-melt Charcoal Iron; Si 1.83 per Cent. Transverse Strength 3,500 lbs.

comparing results, the gates and unused portions of the samples were remelted in a Booth ladle-type muffled arc furnace. The ladle was lined with a mixture of ganister and Thermolith cement. The pig-iron samples were cut up, placed in this ladle, covered with charcoal and heated to the required temperature for pouring. It was endeavoured to

keep this temperature approximately 1,425 deg. C. In general, with the furnace hot, from 30 to 40 minutes were required to bring the charge up to the required temperature. The temperature of the iron in the ladle was noted by means of an optical pyrometer. As soon as a satisfactory temperature was obtained, the ladle was removed from the furnace and the iron poured into an arbitration mould made strictly in accordance with the specification of the American Society for Testing Materials. Usually about one-half minute was required for the pouring the iron, and on no occasion did more than a minute elapse between the time of taking the temperature reading and the pouring of the iron.

This furnace made possible a fairly accurate control of the pouring temperature. That the melting conditions were very satisfactory can be seen from Table II by noting the small variations in chemical compositions between remelts. Likewise it was possible to clean the ladle after each heating, and thus eliminate the possibility of contamination of succeeding samples. Great care was taken to see that this contamination did not occur.

The same procedure was followed for testing the samples thus obtained as was used in the case of the original samples received from the blast furnaces. The samples obtained by remelting were stamped with the same reference number and a prefix X to show that they were remelts.

Table I.—*Physical Properties of Remelted Charcoal Irons.*

Iron No.	Si	Mn	S	P	C	Brinell	Transverse pounds	Deflection inches	Tensile strength pounds per square inch
X11	1.27	0.53	0.012	0.136	4.11	167	3,200	0.15	28,850
X66	1.34	0.43	0.012	0.149	4.08	159	2,750	0.165	24,800
X69	1.41	0.54	0.011	0.138	4.09	163	2,850	0.16	25,200
X70	1.48	0.61	0.012	0.147	3.97	158	2,800	0.145	25,400
X49	1.65	0.44	0.008	0.140	3.90	175	3,050	0.12	29,200
X50	1.52	0.41	0.01	0.136	3.99	179	3,300	0.17	28,500
X0	1.70	0.62	0.012	0.136	3.96	163	3,000	0.155	25,850
X68	1.81	0.56	0.012	0.162	4.07	159	3,150	0.205	24,800
X73	1.82	0.43	0.010	0.166	4.05	159	2,700	0.14	25,900
X60	1.90	0.70	0.009	0.133	3.90	195	3,700	0.19	29,800
X64	1.91	0.61	0.013	0.137	4.04	179	3,450	0.13	29,900
X79	2.04	0.54	0.011	0.140	4.00	170	3,350	0.13	27,400
X75	2.15	0.48	0.009	0.166	3.86	170	3,200	0.13	30,400
X74	2.47	0.49	0.009	0.137	3.79	167	3,500	0.16	27,000
X72	2.57	0.53	0.008	0.131	3.81	161	3,150	0.15	28,500
X47	2.64	0.54	0.008	0.176	3.60	159	2,500	0.13	21,200
X76	2.84	0.62	0.009	0.145	3.78	167	3,650	0.135	31,500
					AVERAGES	167	3,135	0.152	27,247

Table II.—*Physical Properties of Remelted Coke Irons.*

Iron No.	Si	Mn	S	P	C	Brinell	Transverse pounds	Deflection inches	Tensile strength pounds per square inch
X6	1.70	0.91	0.015	0.133	3.91	151	2,750	0.15	23,500
X37	1.99	0.78	0.033	0.176	3.83	152	2,450	0.17	21,600
X7	2.06	0.74	0.016	0.133	3.89	163	2,900	0.14	25,600
X18	2.09	0.95	0.029	0.520	3.74	165	2,850	0.15	22,600
X22	2.09	0.99	0.04	0.50	3.73	163	2,600	0.12	21,000
X36	2.10	0.71	0.026	0.163	3.72	147	2,650	0.155	17,100
X4	2.11	0.74	0.027	0.135	3.85	151	2,300	0.13	21,600
X19	2.21	0.74	0.033	0.46	3.62	154	2,600	0.15	19,000
X38	2.42	0.80	0.023	0.504	3.51	161	2,550	0.12	22,400
X23	2.44	0.97	0.026	0.464	3.64	166	2,600	0.15	21,000
X3	2.88	0.95	0.020	0.19	3.56	149	2,700	0.105	21,500
X20	3.25	1.03	0.024	0.48	3.44	156	2,500	0.15	20,600
X5	3.27	0.82	0.026	0.273	3.47	116	2,300	0.10	18,200
X1	3.31	0.89	0.023	0.45	3.32	140	2,030	0.10	19,100
X2	3.67	0.93	0.024	0.458	3.33	129	2,200	0.10	18,200
					AVERAGES	150	2,533	0.132	20,806

Table III.—*Effect of Remelting on Properties of Pig-irons.*

Iron No.	Si	Mn	S	P	C	Brinell	Transverse pounds	Deflection inches	Kind of iron
60	1.98	0.70	0.009	0.133	4.19	156	2,700	0.16	Charcoal.
X60	1.90	0.70	—	—	3.90	195	3,700	0.19	
XX60	1.83	0.67	—	—	3.79	170	3,500	0.18	
64	2.02	0.70	0.012	0.137	4.17	153	2,600	0.16	Charcoal.
X64	1.91	0.61	0.013	0.136	4.04	179	3,450	0.13	
XX64	1.87	0.57	0.015	0.139	3.96	167	3,300	0.13	
37	2.01	0.81	0.028	0.163	4.20	131	2,400	0.15	Coke.
X37	1.99	0.78	0.033	0.176	3.83	152	2,450	0.17	
XX37	2.03	0.71	0.038	0.173	3.80	131	2,300	0.115	
18	1.95	0.94	0.029	0.520	3.85	159	2,500	0.125	Coke.
X18	2.09	0.95	—	—	3.74	165	2,850	0.15	
XX18	2.06	0.95	—	—	3.74	170	2,800	0.12	
75	2.20	0.49	0.009	0.166	4.04	171	2,500	0.14	Charcoal.
X75	2.15	0.48	—	—	3.86	170	3,200	0.13	
XX75	2.11	0.45	—	—	3.82	153	3,000	0.12	
74	2.69	0.49	0.009	0.137	3.83	137	Holes	—	Charcoal.
X74	2.47	0.49	—	—	3.79	167	3,500	0.16	
XX74	—	—	—	—	3.67	166	3,550	0.13	
47	2.72	0.54	0.008	0.176	3.64	160	2,360	0.105	Charcoal.
X47	2.64	—	—	—	3.60	159	2,500	0.13	
XX47	2.56	0.48	—	—	3.53	149	2,800	0.135	
76	3.02	0.65	0.009	0.145	3.78	158	2,600	0.13	Charcoal.
X76	2.84	—	0.009	0.139	3.78	163	3,650	0.135	
XX76	2.86	0.65	0.009	0.131	3.72	170	4,000	0.135	
2	3.63	—	0.023	0.45	3.55	127	2,200	0.12	Coke.
X2	3.67	0.93	0.024	0.458	3.33	128	2,200	0.10	
XX2	3.70	—	0.028	0.463	3.20	116	2,100	0.125	

XUM

Data Obtained on Remelting.

The remelted irons are tabulated in the order of their silicon content. This order is not exactly the same because the silicon losses on remelting varied. The variations are not great, however, averaging only 0.05 per cent. loss of silicon and 0.02 per cent. loss of manganese in the remelting. Only a few values for phosphorus and sulphur were determined, and as these checked within the limits of chemical error with those for the original samples, it was deemed unnecessary to make further analyses for these elements. It is evident from the chemical analysis that the melting conditions were slightly oxidising.

FIG. 8.—No. 37 UNETCHED × 100 COKE PIG-IRON; Si 2.01 PER CENT. TRANSVERSE STRENGTH 2,400 LBS.

Differences in Strength Greater on Remelting.

From the data recorded in these tables, it will be seen that the differences in strength are even greater between the charcoal and coke irons than was the case before the remelting. A comparison of the tables will show that coke irons did not increase materially in strength on remelting. In general, the charcoal irons showed a decided increase in physical properties on remelting. This is probably due to the less favourable pouring conditions of the original samples already mentioned.

The Brinell readings on the coke irons given in Table III range from 116 to 166, while those for charcoal irons given in Table I range from 158 to 195. A comparison of tensile strengths for the two shows that the coke irons range from 7.6 to 11.4 tons, while the charcoal samples range between 9.4 and 14.0 tons per sq. in. The average tensile strength for coke iron, 9.3 tons per sq. in., is below the lowest value found for charcoal iron, and the average tensile strength for charcoal iron, 12.2 tons per sq. in., is above the highest value for coke iron. This same relation is evident for the transverse strengths. The coke irons vary between 2,030 and 2,900, with an average of 2,532 lbs.; whereas, the charcoal samples give minimum and maximum values respectively of 2,500 and 3,700, with an average value of 3,188 lbs.

FIG. 9.—No. X 37 RE-MELTED COKE PIG-IRON; Si 1.99 PER CENT. TRANSVERSE STRENGTH 2,450 LBS.

Fig. 1 showing the transverse strengths and Fig. 2 giving the tensile strengths, will perhaps present the picture more forcibly than it may be obtained from a comparison of the tabulated data. The data is plotted on silicon content as the abscissa.

These figures, which represent the averages of many tests, prove that there is good agreement between the strengths of the irons and the methods used to produce them. There can be little doubt that the coke irons tend to be weaker than the charcoal irons. Furthermore, the difference appears to be a chemical one because it persists through the remelting of the iron. Examination of Table III shows this difference to persist through a second remelt and removes any question of its effect.

Silicon Effect Does Not Show Well-Defined Relationship.

Strangely enough there is no well-defined relation existing between the silicon content of the irons and their physical properties or between any of the commonly determined chemical elements and these physical properties. It must be borne in mind, however, that the effect of the silicon is minimised by the use of dried moulds and the 1¼-in. section.

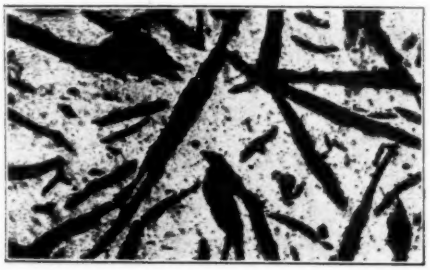


FIG. 10.—No. XX 37 UNETCHED × 100. SECOND RE-MELT COKE IRON; Si 2.03 PER CENT. TRANSVERSE STRENGTH 2,300 LBS.

These statements do not mean that the physical properties would not be influenced by the addition of material quantities of these elements. They merely mean that within the limits in which the elements are present in the irons listed, they do not appear to account for the marked variations in properties which are noted.

Second Remelt Made.

In order to show that the results obtained on the first remelt were peculiar to the iron, rather than the melting conditions, some of the irons were remelted a second time. Similar physical and chemical tests were made on the sample resulting from the second melting as in the first two cases. These samples were given the same number as the samples of previous melts, and the prefix XX was used to denote the second remelt.

The data resulting from this set of tests is tabulated in Table V, together with the data on the previous heats for the same irons. It will be observed that the characteristics of the irons were changed but very little by the second remelting, proving that the results obtained on the first remelt were reliable and not the result of any irregularities in the melting conditions.

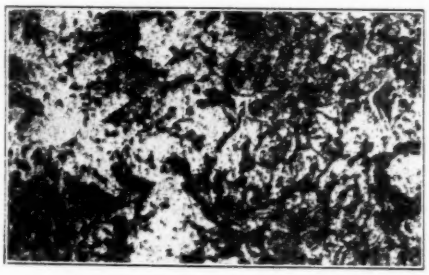


FIG. 11.—No. 76 UNETCHED × 100. RE-MELTED CHARCOAL PIG-IRON; Si 3.02 PER CENT. TRANSVERSE STRENGTH 3,650 LBS.

Fig. 3 gives graphically the percentage error in the transverse breaking loads obtained after the first and second remelts. The maximum difference is 12 per cent., while the average is approximately 5 per cent.

Fig. 4 gives the comparative strengths of coke and charcoal irons of practically the same chemical composition. It is practically impossible to get different samples from the furnaces and remelt them to give exactly the same metalloid

content. It is believed that the irons compared are near enough alike in this respect to show conclusively that there is a decided difference in the characteristics which cannot be accounted for by a difference in chemical composition as commonly determined.

Comparison of Test Results.

Irons Nos. X60 and X64, having a silicon content of 1.90 and 1.91, can be compared with iron No. X37 with a silicon content of 1.99 per cent. The manganese, sulphur, and phosphorus contents are very nearly the same, and yet No. X60 has a tensile strength of 29,800 lbs. per sq. in.; No. X64, 29,900 lbs. per sq. in., while the tensile strength of No. X37 is only 21,600 lbs. per sq. in. Again, the transverse strength of No. X60 is 3,700 lbs.; No. X64 is 3,450 lbs., while the transverse strength of No. X37 is only 2,450 lbs. Remelting and

Fig. 12.—No. X 76 Unetched × 100 Re-melted Charcoal Iron; Si 2.84 per Cent. Transverse Strength 3,650 lbs.

retesting these three irons gives a transverse strength for No. XX60 of 3,500 lbs.; No. XX64 of 3,300 lbs., and No. XX37, 2,300 lbs. The two irons, Nos. X60 and X64, having about the same strength, average 38 per cent. stronger in tensile strength and 46 per cent. stronger in tranverse strength than No. X37. Remelting and retesting these three irons showed them all to be practically the same strength as before and so still showed irons Nos. X60 and X64 to be 46 per cent. stronger than No. X37. These irons have practically the same chemical constituents, the only known difference between them is that Nos. X60 and X64 were made by the charcoal process, while No. X37 was made by the coke process.

The same comparisons can be made between

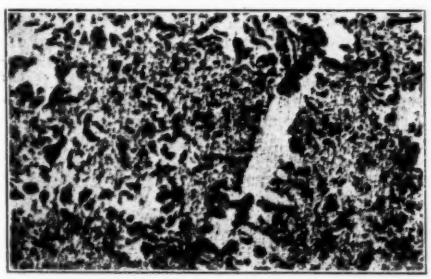


Fig. 13.—No. XX 76 × 100 Second Re-melt Charcoal Iron; Si 2.86 per Cent. Transverse Strength 4,000 lbs.

No. X74, a charcoal iron, which averages 28 per cent. stronger than No. X38, a coke iron; No. X75, a charcoal iron which averages 40 per cent. stronger than No. X4, a coke iron; and between No. X76, which averages 41 per cent. stronger than No. X3, a coke iron. The outstanding difference which corresponds to difference in strength between these irons is the process of manufacture.

Microstructure Shows Differences in Graphite Formation.

An important differential between these strong and weak irons has been noted. This is in the microstructure. As was stated at the beginning of this Paper, over one hundred irons have been examined in collecting these data. One of the most pronounced differences in all the specimens examined was the formation of the graphite flakes. These flakes in the weak irons are long and cut the matrix of ferrite at many angles. In the stronger irons, the graphite flakes are much smaller, and the ferrite has better continuity. Examination of the photomicrographs in this Paper will show this difference better than it can be described. Four irons are shown, two coke irons and two charcoal irons, each as pig-iron, first

Fig. 14.—No. 2 Unetched Coke Pig-Iron; Si 3.63 per Cent. Transverse Strength 2,200 lbs.

remelt and second remelt. All of the microsections were made from the 1¼-in. transverse test bars close to the fracture caused by the transverse test. All of the photomicrographs are in the unetched condition and magnified 100 times. As will be observed, there is a general tendency for the graphite flakes to remain the same through the remeltings, although in both charcoal irons the

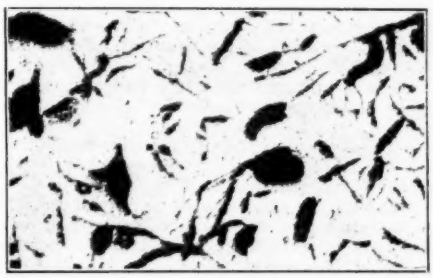


Fig. 15.—No. X 2 Unetched × 100 Re-melted Coke Iron; Si 3.67 per Cent. Transverse Strength 2,200 lbs.

graphite flakes seem to be refined in the first remelt. It may be that the poor casting condition as previously described caused the flakes to be rather coarse in the pig-iron. There appears to be little tendency for the graphite in the coke iron to be refined in remelting.

The writer does not claim that all coke irons look like Nos. 37 and 2, nor that all charcoal irons

Fig. 16.—No. XX 2 Unetched × 100 Second Re-melt Coke Iron; Si 3.70 per Cent. Transverse Strength 2,100 lbs.

look like Nos. 60 and 76. The stronger coke irons have smaller flakes than the weak coke irons, and the weak charcoal irons have larger flakes than the strong ones. However, there is a distinct tendency for the coke irons to have large flakes and for the charcoal irons to have small flakes.

While this difference in microstructure has been

observed, no reason for its cause can be given. It is logical enough that the strength of the metal should vary with the size of the graphite flakes, but what causes the variation of the graphite flakes? The author hopes that further work may be done on this problem and that some relation will be found between blast-furnace conditions and the production of high-grade iron, so that the variation in characteristics of pig-irons of the same chemical analysis may be controlled, and poor pig-irons eliminated.

Spindle Work.

By J. H. LIST.

A method of making a mould for a circular dryer pan is by the use of strickles or sweeping boards. Owing to the peculiar shape of the bottom, the casting is very liable to crack when cooling. As soon as possible after the metal has been poured the mould is turned over on its side and the bottom bared. If kept covered up, the outer case will finish contracting long before the bottom. Under these conditions the bottom still contracting would pull against the case and crack it, as it will be noticed the case walls are not very thick.

Strickle work of this nature is quite common practice in some shops, but the writer is giving this example not so much as instructing of how to make the pan but to try and bring out the small points which generally lack the attention they should get.

The strength of this spindle entirely depends on the diameter of the casting. The diameter, however, should be such that it is when divided by 2, a figure that is easy to work, and calculate with the dimensions of the drawing. For instance if the spindle is 2 in. dia., the centre of the spindle is 1 in. from the edge, and such a figure is easily added on to or subtracted from any calculation in setting out the work. The writer once had a spindle which was 9/16ths dia. so that each time any adding up of figures was required he had to reckon with 25/32nds, which is hopeless.

The spindle base or socket is next required. The boss in which the spindle revolves should be of ample length, at least 6 in. for a medium job, and should be carefully machined out to fit the machined taper on the end of the spindle. Casting this boss round the spindle is not sufficiently good. Such a method does not give a good fit and allows of a side motion, and with this the moulder cannot be expected to make a true mould, nor can the pattern-maker govern the size correctly.

The arm or arms to which the wood strickles or sweeping boards are fastened must be stiff and of ample size in depth and thickness, otherwise the pattern-maker cannot be expected to secure his sweeping boards safely. Some fasten the arms to the spindle and in sweeping, the spindle revolves, others allow the spindle to be stationary, and the arm revolves round it. The writer prefers the former, because the spindle where it revolves in the socket at the base is taper, and any wear is better taken up, whereas the arm boss must be parallel to enable it to slide up and down the spindle, and wear would, in course of time, make an oval hole and, at the best, soon give play.

The spindle, when being set, must be plumb and the base firm and solid. The strickles or sweeping boards must be of ample dimensions to ensure them from springing or giving in any way.

The moulding box in which the job is going to be done must be strong and rigid, and should have good bars, bearing in mind that usually such moulds are carried by the crane into the drying ovens, and some cranes creak a little and is liable to cause a drop out. In setting the box care should be taken to get it fixed level, in the way the spindle which has been fixed plumb will be at 90 deg. to the box joint.

Care should also be taken that the sufficient space has been allowed for the runner gates and risers when setting the spindle in relation to the box.

Fig. 1 shows the pan upside down, and as it is strickled. After the spindle-base has been fixed and the drag part placed over it, the moulder commences by ramming up in loam and strickles the first joint at A, B. Vent well, and when finished dry in the stove. The box should be well-barred, as this drag will have to carry the centre core later. The moulder then puts on the middle part and fills up with floor sand, and rams tight to the top.

The strickle is then fixed on X and the joints at C, D swept up. As this is only a temporary measure venting is not yet required.

After putting on the core the mould is rammed up, using facing sand in the usual way. The spindle may be left in.

The down-rights and risers are then cut. These should be in opposite corners, the two down-rights being connected to one common, filling bush and the risers to have a riser-bush to each.

After well venting the top, it is taken off, the mould face finished off with a facing, and when ready, it is taken to the drying stove.

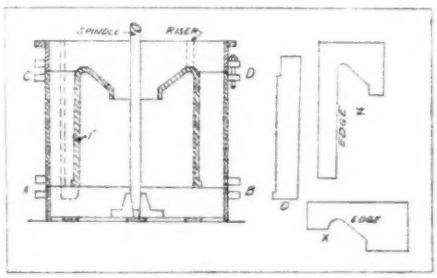


FIG. 1.

The centre is again dug out, the strickle board O is fixed to the spindle and the middle portion swept up to the correct height. It is well vented and the face of the mould is finished as before, when the middle part can be taken to the drying stove. The down-rights, being formed with tubes when ramming up, must be examined to ascertain that they correspond with those formed in the top part. They must be withdrawn before taking into drying stove. The strickle Z is then fixed to the spindle and the core built up, using bricks to within about 2 in. of the face of the casting.

The mould is well vented to the centre and finished off in the usual way. Then the drag part is removed to the drying stove.

It will materially help, when ramming up the middle part and the bottom part forming the core, to use a circular pattern about the correct size if available, or if not, it must be bricked up. This will give something to ram against, after which it can then be strickled off to proper size.

In replacing the parts, care must be taken to test the joints for being in good contact or a "run out" will be the result. The spindle is withdrawn before the assembling of the parts is started and it forms a good vent to the whole of the mould, particularly the core.

The Depression in the Steel Trade.

The problems, industrial and technical, now facing the iron and steel trades in Scotland, were discussed by Mr. E. H. Lewis in the course of his presidential address to the West of Scotland Iron and Steel Institute at the opening meeting held in the Royal Technical College, Glasgow.

Mr. Lewis said that at the present moment the outlook for their trade was about as dismal as it could be. After indicating the fall in the market value of capital invested in the industry and the decrease in production, he said their trouble was that they could not get their costs down sufficiently to compete in many of the world markets. Demand for steel throughout the world was much below capacity, and only the producing countries that could get the lowest cost could have reasonable employment.

In France, Belgium, and Luxemburg they had got over their difficulties, and, according to figures quoted, were increasing production. Probably 80 per cent. of their cost of steel was made up of wages. The price of plates here was £9 15s., 80 per cent. representing a wage cost of £7 16s., while the corresponding Continental figure would be £5 1s. 5d., giving a margin of £2 14s. 7d. a ton. In shipbuilding an increase of ships in hand went with increased imports of pig-iron and steel plates.

The Influence of Sulphur in Cast Iron.

By J. E. Hurst.

During the last few years the importance attached to the presence of sulphur as a source of certain troubles appertaining to grey iron casting has considerably declined. This fact is to be attributed to the more general knowledge amongst foundrymen of the actual mechanism of the behaviour and influence of this constituent. Keep, in his book, considers that a percentage of sulphur of 0.05 per cent. will have no deleterious influence, and that any such influence is simultaneously corrected by the silicon content. Moldenke, writing in 1921, states that it is possible to make serviceable and machineable castings with sulphur as high as 0.30 per cent. Moldenke points out that it is necessary to use every care in using such high-sulphur contents.

The American Society for Testing Materials, in June, 1923, advanced the limit of sulphur to 0.18 per cent. in the tentative specification for chilled-iron car wheels, as a result of tests made and submitted by the Wheel Manufacturers' Association.

British foundrymen, notably Mr. F. J. Cook and others, have for some considerable time recognised the fact that high-sulphur content in cast iron need not necessarily be deleterious, and the influence of sulphur is worthy of detailed study on the part of foundrymen.

The Existence of Sulphur in Cast Iron.

Sulphur is invariably present in all commercial cast iron in the form of sulphides of iron and manganese. The sulphur is principally absorbed during the production of pig-iron in the blast furnace from the sulphur compounds—pyrites and calcium sulphate present in the ores and fluxes. The series of typical analyses of an East Coast pig-iron given below in Table I serve to demonstrate the well-known fact that the amount of sulphur absorbed under blast-furnace conditions varies inversely with the amount of silicon present in the pig-iron.

Table I.—*East Coast Hematites.**

	Tot. C.C.	C.	Gr.	Si.	Mn.	S.	P.
No. 1 ..	0.30	4.02	3.72	2.50	1.00	0.02	0.05
No. 2 ..	0.45	3.47	3.52	2.25	1.00	0.03	0.05
No. 3 ..	0.56	3.71	3.15	2.00	1.00	0.04	0.05
No. 4 ..	1.00	3.75	2.75	1.50	1.00	0.10	0.05
No. 5 ..	1.55	4.00	2.45	1.00	0.75	0.20	0.05
Mottled	2.05	3.55	1.50	0.75	0.50	0.25	0.05
White ..	3.15	3.15	trace	0.65	0.50	0.30	0.05

The gradual increase in sulphur with decreasing silicon contents is well illustrated in this series. It is a natural assumption to make from figures of this nature that the silicon is the active agent in removing the sulphur from the molten metal. Dr. Stead has shown this, and demonstrated that when iron silicide is formed, sulphur is reduced, and the fluid basic silicate slag dissolves sulphur from the iron at temperatures of 1,150 deg. to 1,300 deg. C. It is highly probable that the reduction of sulphur by the iron silicide is a reaction of the reversible type, but it is quite certain that equations of the type given by Fletcher,† involving the iron silicide Fe_2Si are, in the author's opinion, wrong, as this compound does not exist.

Mr. E. L. Rhead,‡ as a result of his investigations, considers that silicon at high temperatures in the presence of lime decomposes the lime, forming silicon, which enters the iron direct as iron silicate, and liberates calcium, which, in its turn, combines with the sulphur, forming calcium sulphide, which passes into the slag. The desulphurising processes of Saniter and others, which essentially consist of treating large baths of molten metal with calcium fluoride, act by these and similar reactions. The relationship between the sulphur silicon and temperature conditions in the working of the blast furnace is tacity accepted by Messrs. Royster and Joseph. From an investigation of the temperatures attained in a number of blast furnaces these investigators were able to deduce a formula connecting the temperature with the sulphur and slag conditions. This interesting formula is as follows:—

$$T = 1521 + 30\,S - 61\,B - 1.6663$$

Where T = temperature of metal.
S = per cent. sulphur in slag.
B = ratio $\frac{CaO + MgO}{Al_2O_3 + SiO_2}$ in slag.

The quantity of sulphur present in various grades of pig-iron is usually a fairly constant quantity of small magnitude for any particular make of iron. In foundry irons having an average silicon content of 2 per cent., the sulphur content of the pig-iron rarely exceeds a value of 0.08 per cent. The operation of re-melting the pig-iron in the foundry cupola invariably results in a further absorption of sulphur from contact with the coke, the amount of which depends largely on the character of the coke used and the character of any scrap additions made during this re-melting. Probably the average normal practice to-day is to produce castings containing round about 0.10 per cent. sulphur.

Dr. Moldenke has drawn attention to the gradual increase which must be steadily occurring in the sulphur contents of commercial cast iron. This is inevitable, and must result from the continued use of scrap cast iron in which the sulphur content is steadily increased according to the number of times the scrap has been re-melted.

The use of limestone in sufficient quantities in the melting of cast iron in the foundry cupola has the tendency to prevent the absorption of sulphur. The use of manganiferous shales or schists, and also of calcium fluoride addition, in the cupola have been suggested to prevent sulphur absorption in the cupola. The former is likely to yield good results in those districts where such ores are readily available. The latter was much in favour in the United States, and to a limited extent in this country. Some results (Table II) obtained by the author using calcium fluoride flux are of interest:—

Table II.—*Influence of Slag Additions on S. content.*

Cast No.	% Sulphur.	Additions.
4.11	0.089	50 to 60 lbs. Limestone per ton.
12.11	0.058	30 lbs. Fluors ,,
13.11	0.076	40 lbs. ,, ,,
14.11	0.058	10 lbs. and 30 lbs. Limestone ,,

Whilst these tests were taken from the same mixture of irons running on different days, it may be taken that the reduction in sulphur content was principally due to the fluorspar additions.

The Condition of Sulphur in Cast Iron.

It is well known that the condition of the sulphur in cast iron depends upon the amount of manganese present in the alloy. In iron-carbon alloys, as was shown by Prof. Arnold, the sulphur exists as the iron-sulphide compound FeS. Later, Prof. Arnold showed that in the presence of manganese the sulphur was combined with this constituent. The influence of the sulphur on the properties of steel was shown to be most marked according to whether the sulphur existed combined with the manganese or the iron. In the former case, its general influence on the strength properties was practically nil, and in the latter case it was found to be both detrimental to the strength and also the forging properties.

In a like manner in cast iron the existence of the sulphur as the manganese or the iron compound has a profound influence in determining whether or not it will seriously modify the properties of the iron.

It has been shown by various investigators that the addition of manganese to cast iron in which sulphur exists as iron sulphide results in the formation of manganese sulphide. The probable reaction is indicated by the equation

$$FeS + Mn = MnS + Fe.$$

* Adamson, Sheff. Soc. of Engs. and Metallurgists.
† J., Staffs. I. & S.I.
‡ J., West of Scot. I. & S.I. Vol. iv., page 102.

Theoretically, one part of sulphur requires 1.73 parts of manganese to form the manganese sulphide. In actual practice in cast iron it is found that considerably more manganese is required to convert the iron to the manganese sulphide. In connection with steel, Dr. Stead has stated* that at least eight times the theoretical amount of manganese is required to neutralise the sulphur. Levy, in discussing this point, considers that the excess of manganese required is likely to be greater in the low-carbon alloys than in cast iron. Various other workers have investigated this point, including Schutz, Hackney, Thomson, and Hilgenstock, and it has been suggested that the above reaction is probably to be considered as a balanced reaction determined by the temperatures and concentrations of the constituents on both sides of the equation.

Dr McCance has fully considered this suggestion, and conclusively disproves it. The explanation he advances to explain the practical observation that excess of manganese is required to neutralise the sulphur is that a portion of the manganese is invariably occupied by some other constituent, so that only a portion of the added manganese goes to satisfy the sulphur. With this explanation the writer is in agreement, and in cast iron it is probable that the carbon invariably takes its share of the manganese present.

In the absence of manganese, the sulphur exists as the iron sulphide, and in percentages up to 0.9 per cent. of sulphur in cast irons containing 2.73 per cent. of carbon, Levy has shown that this iron sulphide consituent is soluble in the iron, and exists uniformly throughout the mass. Immediately the percentage is exceeded, the sulphide was found to be irregularly distributed throughout the sample. Treitshe, Tamman, and Friedrich find that the solubility of the sulphide in iron free from carbon is less than 1 per cent., and they showed an interesting fact that in the presence of oxides and silicates there was a marked tendency to the lack of miscibility in the system.

The Influence of Sulphur in Cast Iron.

The most complete systematic cast iron is that already referred to by Levy. These experiments clearly showed that with increasing sulphur in the absence of manganese the formation of graphite was prevented. Wüst has also shown that in irons containing 3.15 per cent. carbon and 1 per cent. of silicon on an average 0.01 per cent. of sulphur prevents the separation of 0.02 per cent. of graphite, but with 2 per cent. of silicon the effect is much less.

Levy investigated the cooling curves of his complete series of alloys, and the general features of these curves are summarised as follows:—(1) A considerable lowering of the primary solidification point (the Austenite), separation is noticed with increasing sulphur contents; (2) a lowering of the 4.3 per cent. eutectic solidification point was noticed in certain of the alloys. Levy attached considerable importance to this, but it cannot be regarded as sufficiently conclusive; and (3) the absence of an arrest on the curves of melts within the saturation limits of about 0.8 per cent. sulphur.

The addition of manganese in neutralising this influence of sulphur has been repeatedly shown in isolated experiments, both by Dr. Stead and others. This is on a par with the influence of such additions to steel.

The Reason for the Effect of Manganese.

Numerous investigators have shown that the sulphide of manganese has a comparatively high melting-point, and also is insoluble in molten cast iron at the temperatures commonly met with in commercial practice. Various figures have been given as the melting-point of manganese sulphide. Levy found a melting-point of 1,400 deg. C. The most careful work of Rohl on the iron and manganese sulphide system, he found a melting-point of 1,620 deg. C. for the manganese sulphide. McCance considers this to be the most reliable determination of the melting-point, and attributes the lower figures obtained by other workers to the presence of manganese oxide dissolved in the sulphide. Manganese sulphide containing 9 per cent. of manganese oxide can be quite easily fused at 1,400 deg. C. The diagram given by Rohl is illustrated in Fig. 1. The evidence for the existence of the double compound $Mn_3S_2Fe_2$ is very slight, and from the data given in his experiments, there is no necessity to consider the

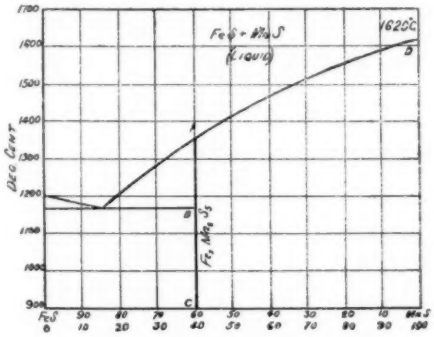


Fig. 1.—Rohl's FeS—MnS Constitutional Diagram.

point A as being anything other than the limit of the saturated solid solution of FeS in MnS.

Probably the most striking evidence of both the insolubility of manganese sulphide in iron, and also its lower specific gravity and its lack of influence on the condition of the carbon, is to be found in the experiment published by the writer in connection with the centrifugal casting process. The illustration Fig. 2 is taken from a sulphur print of the cross section of a large turbine gland casting, cast by rotation of the molten metal at a high speed in a metal mould. In a thick casting of this nature the period of solidifi-

Fig. 2.—Sulphur Print from Cross Section of Centrifugal Casting, Half Actual Linear Size.

cation of the casting as a whole occupies an appreciable time, and under the influence of the centrifugal action the manganese sulphide is separated to the inside surface of the casting. This fact alone is conclusive evidence of both the insolubility and the lower specific gravity of the manganese sulphide. Analyses taken from the body of the casting and the segregated centre gave the following results:—

	Body. %	Centre. %
Mn.	0.60	0.33
S.	0.23	0.06

In spite of the high sulphur content in the centre portion of the casting, there is none of the hardening effect noticed in the absence of manganese, and there is no apparent change attributable to the sulphur content. It is also of interest to note that the manganese content is considerably in excess of the requirements of the formula MnS. If, however, we deduct from the 0.33 per cent. manganese present in the body of the casting the quota of manganese corresponding to the 0.06 per cent. sulphur present, we obtain a value of 0.2268 per cent. Mn, which can be regarded as the amount of manganese not in combination with the sulphur, and as uniformly distributed throughout the whole specimen. Deducting this amount from the 0.60 per cent. sulphur present in the central portions, we obtain a value of 0.3732 per

* J.I.S.I., No. 1, page 146, 1903.

cent. sulphur as being that portion in combination with the 0.23 per cent. sulphur at this point. This value is sufficiently near the theoretical requirements of 0.3979 per cent. to correspond to the formula MnS as could be expected under these circumstances

This, and similar experiments by other workers, demonstrate quite clearly that the influence of manganese is due to its converting the sulphur into the insoluble form, in which condition it has no influence on the condition of the carbon. We may also expect that the influence of the sulphur in the form of the iron sulphide is to be ascribed to its solubility in the iron.

The Influence of the Iron Sulphur Compound.

In steels the influence of the iron sulphide compound in inducing brittleness and bed shortness has been shown to be due to its solubility in the liquid steel and its separation on solidification as a brittle eutectic between the grains. The mechanism of the influence of iron sulphide in cast iron has been investigated by various workers, including Levy, Stead, and Hatfield, in this country. The work of Levy has already been referred to, and he considered that the continuity of the eutectic freezing-point, and also the Ar. 1, 2, 3 points, has something to do with this influence of sulphur. From the microstructure of his various alloys, Levy concluded that the presence of sulphur in the form of iron sulphide prevented the "balling up" of the cementite carbide which he hypothesises as a necessary preliminary to the formation of graphite. With this view Hatfield is not in agreement. He has found, and all malleable ironfounders know, that the carbide can be easily broken down by heat treatment, even in the presence of fair percentages of sulphur. He further suggests that the sulphur exerts some influence in retaining the pearlite structure, and this indicates the influence of sulphur in this form preventing the formation of graphite.

Dr. Stead made a series of experiments which demonstrated that, in the absence of manganese, some of the sulphur was to be found with the carbide Both by analytical methods and beautiful microphotographs, Stead concluded that the carbide will carry in solution not more than 0.1 per cent. sulphur, and since he found that drastic annealing would not precipitate the free carbon in these alloys, he concluded that the sulphur in them prevented the carbon from decomposing. Whether this is quite the correct view requires further experiment to decide, but the writer is of the opinion that it is rather the carbide which is dissolved in the solid solution than that which is dissolved in the carbide, which prevents the formation of graphite. In support of this, and from Dr. Stead's own analyses, it will be found that the major portion of the sulphur dissolved in the alloy is present as dissolved in the Austenite solid-solution. It is perfectly clear that it is the solubility of the iron sulphide which accounts for its influence in preventing the formation of graphite.

The influence of the iron sulphide in cast iron is principally that of preventing the formation of the graphite, and hence the production of hard castings. In this respect there is plenty of evidence that in quantities up to at least about 0.30 per cent. in ordinary foundry irons, containing about 2 per cent. of silicon, that its influence in this respect is not too great. In irons of lower silicon content, or in castings made under conditions or of a character where the rate of cooling either as a whole or locally is likely to be quick, the effect of sulphur in the above amount would be at once felt in hard castings. For general practice, the usual limits of between 0.10 to 0.20 per cent. are quite safe from this point of view, even when present as the iron sulphide constituent wholly. In this respect the influence of sulphur on cast iron is quite different from its influence in steel, and any influence it has on the properties of cast iron are principally to be ascribed to its influence on the condition of the carbon. Sulphur in the form of iron sulphide separates out as a eutectic in much the same manner as the phosphide constituent, and as in the case of this latter we should not expect its influence on the strength properties in itself would be any greater in view of the presence of so much graphite. Taking this into consideration with the fact that in commercial cast iron a large proportion, if not all the sulphur present, exists in the form of the manganese sulphur compound, it may safely be concluded that in percentages up to about 0.30 per cent. the sulphur is practically without influence on the character and properties of commercial cast irons.

When present in the larger percentages, there is a tendency of the sulphides to segregate and form local accumulations of sulphides under some of the many and various cooling conditions which are met with in various castings. This tendency, in the writer's opinion, is no greater than in the case of the phosphide constituent.

Sulphur presumably in the form of the iron sulphide constituent used to be commonly considered as a fruitful source of blowholes in castings. Any discussion on the influence of sulphur in this direction is obviously bound up with consideration of the rest of the composition and the rate of cooling. In iron containing sulphur as the iron sulphide, and cast under conditions as far as the rest of the composition and rate of cooling are concerned, which would have a tendency to produce hard castings, the extent of the shrinkage will be increased and the solidification period shortened. There will thus be a greater tendency to entrap the dissolved gases whilst in the act of being evolved from the solidifying casting. It is probably from this point of view that the idea of the relation between high sulphur and blowholes has arisen.

Examination of Sulphur.

The appearance of sulphide of manganese as a dove-grey coloured constituent under the microscope has often been described. It is often difficult to distinguish this from the graphite, as it very often exists as long, thin, elongated particles, which in cross section have all the appearance of graphite. For the most part, however, the sulphide of manganese exists in the form of more or less globular particles, which always have a

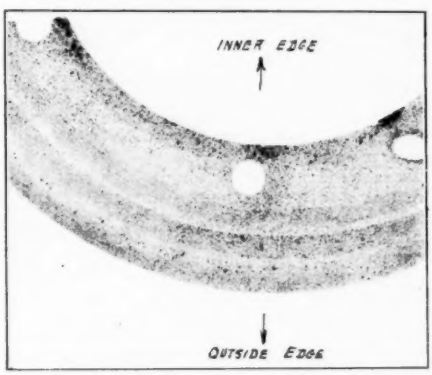


Fig. 3.—Sulphur Print from Cross Section of Experimental Centrifugal Casting, Half Actual Linear Size.

tendency to a polygonal appearance, showing well-defined edge and corners at high magnification.

The sulphide of iron is extremely difficult to identify in commercial cast irons. In the first place it is rarely present in quantities when there is any appreciable manganese content in the iron, and secondly the large quantity of other constituents present make it difficult of separate detection.

The distribution of sulphur can be readily followed by the use of sulphur prints, which are obtained by laying sheets of acidified silver bromide papers on the polished surface of the cast iron to be examined. The sulphuretted gases evolved from the points of sulphide constituent stain the paper brown, leaving a permanent record of the position of the sulphide constituent. Fig. 2 already referred to is an example of this type of sulphur print. Another example is given in Fig. 3 from an experimental centrifugal casting in which the pouring was purposely interrupted. The points of interruption in the pouring are clearly shown by the distribution of the

sulphur and also the local segregation of patches of sulphide on the inner surface of this casting. Sulphur prints of this nature are an invaluable aid to the macroscopic study of cast iron. The position of the insoluble sulphide constituent in a final casting is governed entirely by those same influences, viz., cooling conditions which affect the structure of a casting as a whole, and from this point of view sulphur prints are useful in throwing light on the *modus operandi* of these influences in any particular type of casting.

Summary.

It may be said finally in summarising that sulphur in commercial cast irons in the presence of sufficient manganese exists almost wholly as the sulphide of manganese—MnS. In this form it is practically without influence on the structure and properties of cast iron.

In the absence of sufficient manganese the sulphur exists as the iron sulphide which is soluble in the liquid iron and which has the tendency to prevent the formation of graphite. The actual mechanism of its influence in this respect is still obscure, but is obviously connected with its solubility in the iron.

Additional confirmatory evidence of the insolubility of the manganese-sulphur content, its lower specific gravity, and its lack of influence on the condition of the carbon in cast iron is also given. This evidence approximately confirms the existence of the manganese sulphur content as the simple manganese sulphide—MnS.

Electric *v.* Crucible Tool Steel.

In a Paper on "Making and Use of Tool and Special Alloy Steels," read before the recent sixth anniversary meeting of the American Society for Steel Treating at Boston, U.S.A., DR. JOHN A. MATHEWS (Crucible Steel Company of America) remarked* that crucible steel had an inherent advantage over the electric furnace product because it was in the long run safer to start with good materials carefully selected at leisure than to attempt to refine lower-grade constituents rapidly in the furnace. Then, also, the electric furnace was too often operated by men whose previous experience had been almost exclusively with open-hearth steels. The production of fine steels would always be far removed from "tonnage" operations, but some producers never seemed to learn that fact.

This fact was most apparent in high-speed steels. There was a disproportionate amount of interest and effort spent on it to justify the moderate amount of it sold. One of his Company's plants could easily turn out more than the entire American consumption. Under these circumstances high-speed steel often became a nuisance rather than a source of profit to its producer. This was a regrettable state of affairs, in view of the enormous value this material had been to all metal-working industries.

Since high-speed steel was an alloy of nine elements, some of which existed in more than one form of compound, the complexity of the material was evident. Furthermore, it was used, after proper heat treatment, for such a wide variety of uses and on such a wide variety of metal, that a general specification (especially if based on chemical analysis) would appear to be unworkable. This was especially true in view of the fact that the thermal and mechanical history of the tool was much more important than a small variation in chemical composition in determining the cutting ability.

Early in his experience he (Dr. Mathews) became convinced that uniform conditions were necessary to secure uniform results, either in laboratory or in factory, but when the variables were controlled, a satisfactory result ensued. He therefore enumerated the principal variables in steel as follows: (1) Chemical composition; (2) method of manufacture; (3) manufacturing anneal; (4) quenching temperature; (5) time at heat; (6) time and temperature of draw. Under these circumstances it would be unwise for purchasers to place too much confidence in a specification closely controlling any one of these items, with a corresponding disregard for the others.

* "The Iron Age."

Use of Limestone in Acid Open-hearth Furnace.

BY E. G. SMITH.

To ensure the production of good steel from an acid open-hearth furnace it is necessary to obtain a state of equilibrium between the slag and metal before adding the finishing alloys. Such a condition is indicated by what is known as a "dead melt" metal sample, which is one having a smooth under surface and an upper surface either smooth or perhaps showing surface-tension "ripples." These ripples are indicative of freedom from dissolved oxides. When a bath yields such metal samples, there is a minimum loss on the finishing alloys, and hence maximum freedom from non-metallic inclusions in the finished steel. The production of this "dead melted" condition is facilitated by judicious additions of limestone during the working of the charge.

To give a theoretical explanation of the action of limestone depends on what view is taken of the constitution of the molten slag. If the slag is regarded as an impure solution of ferrous oxide in silica, then the addition of lime reduces its oxidising activity by dilution. A better explanation is obtained by assuming that the slag is composed of the silicates of the various bases in solution. Now lime has a greater affinity for silica than ferrous oxide, and, when added to the slag, first of all combines with any excess silica that may be present. If added beyond this amount it displaces ferrous oxide from combination with silica. This ferrous oxide passes into solution in the metal and is there reduced by the carbon. Limestone, therefore, thins the slag by combining with the excess silica, and, by displacing ferrous oxide from the slag to the metal, acts as a medium for removing carbon. By thus replacing silicate of iron in the slag by silicate of lime, a less fusible slag is produced, and its oxidising activity is diminished by virtue of its increased viscosity. The increased viscosity of a limey finishing slag may be readily seen in the furnace, and, by the way, it draws out like glass wool on the sampling spoons.

Whatever view be taken as to the theoretical action of lime, when making low- or medium-carbon steels, it is quite evident that it is not beneficial to add limestone in the early stages of the boil, since it retards the removal of carbon. On the other hand, large additions of lime should not be made too late on, since limestone takes some considerable time to "work through." The best procedure is to obtain a good vigorous boil with ore and when the boil begins to subside and the slag to thicken, to add limestone with the next feed of ore. The lime affords a base for any excess silica and leaves the oxide of iron free to attack the carbon. As the slag again thickens further additions of ore and limestone are made until the slag sample assumes the desired light green fracture; after this only ore should be used.

After the final "stewing," which gives the bath time to free itself from dissolved oxide, if the metal samples show holes on the underside due to excess silica in the slag, just sufficient small limestone should be added to combine with that excess silica. When a "dead melt" sample is obtained, the final sample must be drawn and the finishing alloys added.

Although limestone is beneficial in the production of a dead-melted condition, excessive additions, even in the early stages, have a very undesirable effect. So much ferrous oxide may be liberated that, by the time the carbon is down to the desired percentage, the oxide has not worked off. The presence of excess lime is revealed by the appearance of the slag and metal samples. The former will have a very light greyish-green fracture with a light-brown surface layer, which does not penetrate to any visible depth into the fracture. The upper surface of the metal samples will be covered with pock marks, giving a characteristic "nibbled" appearance, indicative of reaction between ferrous oxide and carbon. It is possible to stew a bath containing excess lime until the slag is heavy and silicious, with the carbon dropping slowly, and yet it will yield metal samples which are badly nibbled, and this nibbling may persist, even after additions of high-silicon pig.

Institute of British Foundrymen.

LANCASHIRE BRANCH.

The Lancashire Branch opened the session 1924-5 with a meeting held in the Municipal College of Technology, Manchester, on October 4. The Branch-President, Mr. R. A. Miles, was in the chair, and delivered his presidential address, in the course of which he said:

PRESIDENTIAL ADDRESS.

Gentlemen,—It is rather a difficult task to find material for a second Presidential address. Nevertheless, I would like to say at the outset that I feel deeply indebted to you all for the support you have given me during my first year as President, and am looking forward to its continuance. The activities of the Branch Council have resulted in a very creditable syllabus for this session, and Papers will be read to you on many interesting subjects by some of the best known foundrymen. During the year we have had a number of very well-attended works visits, to the London, Midland & Scottish Railway Company's works at Horwich; to Messrs. Howard & Bullough's Works at Accrington; to Sheepbridge Coal & Iron Company's works at Chesterfield, and just lately to the Richmond Company's works at Latchford, Warrington. The thanks of our Institute were tendered to the various Companies' directors and staff in each case. All the visits were well attended, and I am certain they are the means of adding to our membership and give us that opportunity of closer association than is usually possible at our technical gatherings. We are indebted to Mr. Makemson, our hon. secretary, for the admirable arrangements that were made and which entailed a great amount of work and time to ensure the success of these visits.

As I mentioned in my last address, I would like to repeat that there are still a number of excellent foundrymen who, for some reason or another, still remain outside the Institute. We have endeavoured to discover these reasons, which when summed up are generally found under two headings—one is indifference and the other the time of holding our meetings. At our last annual general meeting the latter point was discussed a little, and I would suggest that members study the question deeply and be prepared to make suggestions by letter to our Hon. Secretary during the session, so that if a change is deemed necessary we may have the best of reasons for making such change or not, by an unanimous vote.

We have lost by death several members of the Institute, notably Mr. Robt. Buchanan, the first President, who was the first to suggest an Association of Foundrymen. Mr. Buchanan was a man of kindly disposition, and was always ready to give advice and help to any foundryman who needed it. He was an authority on many foundry subjects, and his death is a great loss to the Institute.

Mr. E. H. Broughall, who until shortly before his death was expected to be President of the Institute this year, but who had to resign his position as senior Vice-President because of illness, will also be missed; and by the death of Mr. W. H. Cook, our own Branch has sustained an irreparable loss. I know you will all extend your sympathy to one of our past Branch Presidents, Mr. Simkiss, who lost his wife by death after a long illness.

Following the decision arrived at at an extraordinary general meeting held at the Station Hotel, Chesterfield, your Council have arranged to have a junor section of this Branch, and I would like to convey my personal thanks to the members of the Council for their prompt and regular attendance at the numerous Council meetings which have been found necessary in order to get this matter settled in time for this winter session. In connection with this junior section we are able to offer a medal to be known as the "John Wilkinson Medal" for competition amongst the members of this section. This has been made possible by a gift of the necessary funds by Mr. J. Thewlis Johnson, of the firm of Richard Johnson & Nephew, Limited, Bradford Ironworks, in this city, and was brought about through the representations of our esteemed member, Mr. J. S. Glen Primrose.

Burnley Section.

We have a section of our Branch holding meetings in Burnley. This section was originally to have a trial run for two sessions, and is now carrying out its fourth campaign. Your Council keep hoping that we may be able to announce that the section will before long be able to become established as a Branch, though this may result in mixed blessings—for we should miss their presence at our meetings, and, by reason of the awkward train service, we should probably get out of touch with many in that area.

Diploma Awards.

You will be glad to know that diplomas have been awarded this year by the Literary Committee to four of our Branch members, namely, to Mr. A. L. Key (past President of the Branch), and foundry manager with Ruston, Hornsby & Company, Limited, Reddish, for his Paper on "Jolt Ramming"; to Mr. Arthur Sutcliffe, a well-respected member of our Branch Council, for his Paper on "Loam Moulding," given at Burnley; to Mr. Francis W. Rowe for his Paper on "Cast Iron" given at Loughborough, and to Mr. S. G. Smith, the junior Vice-President of the Branch, for his Paper on "The Manufacture and Characteristics of Cast Iron" given at a propaganda meeting in Wigan last October. To these four gentlemen I tender hearty congratulations on your behalf and my own.

In conclusion I would like to thank you all for coming along again in such good numbers, and I trust that nothing will transpire during the session to damp your enthusiasm.

Vote of Thanks.

Mr. Haigh moved that the address be placed on the records of the Branch, and that the thanks of the members be given to Mr. Miles for it. At the same time they should express their appreciation of the work which Mr. Miles had done during the past year. It had absorbed a good deal of his time and energy. The visits to works had been numerous and were well attended.

Mr. Masters seconded the motion, which was passed unanimously.

DEATH OF MR. ROBERT BUCHANAN.

Mr. J. S. G. Primrose said when one heard of the death of an esteemed friend it was usual to recall the first and last times of meeting. It was twenty years since he made the acquaintance of Mr. Buchanan on the occasion of the first visit of the British Foundrymen to Glasgow, and he had learned to know him as one of the grand old men of the foundry. By example and precept he had been an inspiration to the younger generation in the industry, and the seed he had sown would yield good fruit during many years.

Mr. Haigh added his tribute of appreciation of Mr. Buchanan's services to the industry. His memory would be cherished as that of an old friend by many among them.

JOHN WILKINSON, A PIONEER OF IRONFOUNDING.

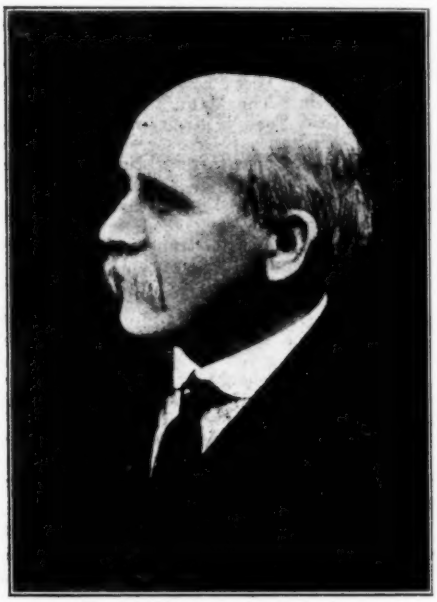
The Chairman said Mr. J. P. Bedson had prepared a short Paper on John Wilkinson, an early pioneer of ironfounding in this country, to be read before the Branch. Unfortunately, Mr. Bedson was in Lausanne, and could not be present at the meeting. So the Paper would be read by the Secretary. The members would no doubt hear with interest the record of Mr. Bedson's own connection with the industry, and he therefore had pleasure in reading the following biographical notes:—

Mr. Bedson, who is a member of the Institutions of Civil and Mechanical Engineers, the Iron and Steel Institute, and the Institute of Metals, is a local veteran of the iron wire trade, and is the third generation of his family to be associated with that trade. He is son of the late Mr. George Bedson, who invented the continuous wire-rod rolling mill, a system which has been copied and extended in America. His father was also the originator of the continuous system of galvanising iron wire, now universally used. These two inven-

tions made the Bradford Iron Works, the Mecca of the wire trade of the world.

Mr. Bedson, after a general engineering training, became in 1872, when little more than 20 years of age, the works engineer at the Bradford Iron Works, under his father, who was general manager. In 1884 he succeeded his father as general manager, and in 1892 he erected at Middlesbrough the first wire-rod rolling-mill plant, accompanied by wire-drawing benches to be operated by individual electric motors totalling 600 h.p.

Returning to Bradford Iron Works, Mr. Bedson about 1909 produced the remarkable 4-holing machines, which enabled wire to be drawn down through four blocks in immediate succession—a most revolutionary innovation. Though Mr. Bedson has now retired, he still retains an active interest in the iron trade, and only last year he was instrumental in inducing Major E. Johnson to present a memorial medal to Manchester University to perpetuate the name of Henry Cort, the inventor of the puddling process and the rediscoverer of the method of using coal instead of charcoal for the smelting of iron, and the originator of the grooved-roll method of producing rods, instead of slitting sheets, as was formerly practised.



JOS. PHILLIPS BEDSON.

Mr. Bedson is keenly interested in educational and scientific work, being the agent who represented Morgan in securing the generous recognition which was so tardily conferred upon the memory of Cort in this country.

MR. PRIMROSE stated that he had received a letter from Mr. Bedson, who noted, with great pleasure, the offer of a medal to commemorate John Wilkinson and his great pioneer work in the iron industry, particularly the section with which the I.B.F. was so closely identified. He believed they were the first to do so. It was a circumstance of additional interest that the donor of the medal, Mr. J. Thewlis Johnson, was the descendant of a firm who made their reputation as ironmasters, not as foundrymen, it was true, but in the puddling and rolling of iron.

MR. MAKEMSON then read the Paper, the substance of which has been published in the Journal of the Iron and Steel Wire Manufacturers' Association, circulated privately, which reads:

John Wilkinson, "Father of the British Iron Trade."

Iron was worked in the Furness district of Lancashire in the middle of the 13th century, and by 1292 a great part of the income of Furness Abbey was derived from the iron made from the local ores—hematite of a very rich quality. Thirty known sites in the Coniston district can be located, and the method of smelting the ore was by charcoal and peat in what were called bloomeries.

Wilkinson's father, named Isaac, began life as a farmer in Cumberland, and eventually went to work at an iron furnace at Blackbarrow, in Cartmel, Lancashire, and here he became foreman. With him his two sons, John and William, worked. Isaac Wilkinson used to tell his own history: "I worked at a forge in the North. My masters gave me 12s. a week. I was content. They raised me to 14s. I did not ask them for it. They went to 16s., then 18s.; I never asked them for the advances. They gave me a guinea a week. Said I to myself, 'If I am worth a guinea a week to you, I am worth more to myself!' I left them and began business on my own account—at first in a small way. I prospered. I grew tired of my leathern bellows and determined to make iron ones. Everybody laughed at me. I did it, and applied the steam engine to blow them, and they all cried, 'Who could have thought it?'"

John Wilkinson, the elder son, was born in 1728 at Clifton, in Cumberland, and was a remarkable man in every respect; in fact, it seems most astonishing that so little is known of him,

JOHN WILKINSON, IRONMASTER, THE INVENTOR OF THE CUPOLA, 1728-1800.

and that his doings have been so completely forgotten.

He must have given early evidence of his ability, for he patented the "Box Smoothing Iron" for laundry work, and this insignificant but useful article, which is only now being displaced by the electric iron, was so successful that it made the foundation upon which his numerous enterprises were built.

Wilkinson was in partnership with his brother and father, their chief business being the manufacture of the above flat-irons for smoothing linen. It is related that John's father brought his iron in the molten state across the high road to the small foundry, by the ladleful, and then ran it into these smoothing irons.

The first iron furnace erected by John was at Wilson House, in Cartmel, for the purpose of smelting the local ore of the Furness district, and from this as a starting point, their undertaking brought about the erection and working by the two brothers of the iron forges at Bersham, near Chester, Bradley, Willey, Brymbo, Snedshill, Merthyr Tydvil, and other places, and they became the largest iron manufacturers of their day.

When about twenty, John moved to Bilston, in Staffordshire, where he erected the first blast furnace in that district. Here he succeeded in utilising the coal of the district instead of the wood (charcoal) for smelting, and I presume he made use later of Henry Cort's invention of puddling iron by mineral coal.

The business prospered, and as the fuel—peat and turf—had to be brought to the iron furnace, John made a canal, which was cut through Turbory, upon which he floated the first iron boat to carry the fuel to the furnace. This was the first iron boat ever constructed. It not only excited the emotions of the local blacksmith, but also created great astonishment along the whole countryside.

The second iron boat was built at Willey, in Shropshire, and was called the "Trial." She was finished in 1787. A great crowd came to witness the launch of this iron barge. A chronicler of the time describes the launching in picturesque language, in which he concludes as follows:—"A discharge of 32-pounders told that all was ready, and before the curling smoke had cleared away the newly christened 'Trial' descended the way-pieces into the River Severn with a splash." Wilkinson, describing the event in a letter, wrote: "Broseley, July 17, 1787. Yesterday week my iron boat was launched. It answers all my expectations, and has convinced the unbelievers, who were 999 in 1,000. It will be a nine days' wonder, and then be like Columbus' egg." Wilkinson went on building other barges, and in a letter dated from Bradley Iron Works, October 20, 1787, he says: "There have been two iron vessels launched in my service since September 1; one is a canal boat for this navigation, the other a barge of 40 tons for the River Severn. The last was floated on Monday, and is, I expect, now at Stourport with a lading of bar iron. My clerk at Broseley advises me that she swims remarkably light, and exceeds even my own expectations."

This, I think, establishes the fact that Wilkinson was the first to make and float an iron boat.

To Wilkinson must be accorded the credit of assisting Watt with his development of the steam engine, for he erected the first steam engine made by Boulton & Watt for operating the bellows for producing the blast for smelting purposes, which had hitherto been done by horses and water power; and he further supplied Watt with such good and perfect cast-iron cylinders as he was unable to secure elsewhere. He further invented a boring method for turning out these cylinders with such smoothness and accuracy that they could not be bettered to-day. These steam cylinders suggested to him the method for producing the blast for smelting purposes, a method which has extended to this day, but is now being replaced by the turbo blower. In 1786 he was making cannons, 32-pounders, howitzers, and shells for both the home and foreign Governments, and with his boring apparatus he turned them out, thus introducing the first step in the perfecting of modern gun-making.

His energies were not confined to this country, for he erected the first steam engine in France—one of Boulton & Watt. A Mr. R. V. Watts, of Hampstead, writing to the "Manchester Guardian" of April 23, 1921, quoted Arthur Young as writing his journal on September 22, 1788, that "Messrs. Epivent had the goodness to attend me in a water excursion to view the establishment of Mr. Wilkinson for boring cannon, in an island in the Loire below Nantes. Until that well-known English manufacturer arrived, the French knew nothing of the art of casting cannon solid and then boring them." Writing at Montcenis (near Schneider's works at Le Creusot) a year later, he cites it as the seat of one of Wilkinson's establishments for casting and boring cannon, the works employing from 500 to 600 men.

The Wilkinsons cast the whole of the tubes, pipes and cylinders, and ironwork for the great Paris waterworks, the most formidable undertaking of the kind at that day. Wilkinson is also credited with being the pioneer of the Silesian iron industry.

A first attempt was made at Lyons to build an iron bridge in 1755, but it was never erected. The honour fell to Wilkinson, who, by his strong and influential advocacy, urged the erection of an iron bridge, at Coalbrookdale, over the Severn. His efforts were successful, and in 1779 the first iron bridge was erected. Pritchard was the architect, and Reynolds and Darby were the builders.

Wilkinson, as was customary in some works in this country at that time, issued copper tokens and silver coins, as well as one-pound notes, payable at his various works. The copper coins have on the obverse side an excellent likeness of himself, and reversely, a forge, metal helve and workman, and, by the side of a pier-head, a ship lying—supposed to be an iron ship.

His efforts in other directions were great and varied, thus: in coking; coal and tar distillation; coal-getting, for which he constructed a machine called the "iron man"; gas-making, prior to Murdoch; and hot blast for blast furnaces, prior to Neilson. Well may he have been named the "Iron King," "Father of the British Iron Trade," "Iron Mad," etc. It was said that he never wrote a letter but the word "iron" was made use of in one way or other.

So imbued was he with the utility of cast iron that he made a cast-iron pulpit, cast-iron coffins for anybody who wanted one—in fact, he made one for himself, and kept it under his bed to show it off with pride. It was made to his measure, but when he died it was too small for him. However, he was buried in an iron coffin in his own grounds, within forty yards of the mansion he built at Castlehead.

In 1828 this estate was sold, and his remains removed to the chapel yard of Lindale, where they now lie, and in this parish there is a large cast-iron obelisk of his own design, and on the base the following inscription:—"Here lies John Wilkinson, Ironmaster, who died July 14, 1808, aged 80 years. His different works in various parts of the Kingdom are lasting testimonies of his unceasing labour. His life was spent in action for the benefit of man, and, as he presumed humbly to hope, to the glory of God. *Labore et Honore*."

The little which is known of Wilkinson's doings can partly be accounted for perhaps by the manner of closing his business career. When the brothers gave up business, labourers were employed to break up the machinery of the works with sledge-hammers, in order that the materials might be equally divided between them. Many thought this an exceedingly insane act, but it was not entirely so. Both were extremely stubborn men, and knew each other's temper, and perhaps they concluded that though sledge-hammers might be very destructive when wielded by labourers amongst their fine machinery, the corrosive though more tedious process of a Chancery suit, managed by skilful lawyers, might be still more damaging to the interest of both, so the machinery was broken up. Despite this precaution, his large property was frittered away by a law suit prosecuted by a nephew against Wilkinson's heirs. Although married twice, Wilkinson left no issue by either of these marriages, and his fortune was left to his natural children, who were specially named by him as his heirs. The case went through various Courts, House of Lords, and Chancery Court, but finally Lord Eldon gave judgment by deciding in favour of the defendants.

MR. PRIMROSE said in August last the "Glasgow Herald" announced that one of John Wilkinson's tokens had been found in a suburb of that city, and a description of it was given. The presence of a portrait of him in the Wolverhampton Town Hall was explained by the fact that he went there from Lancashire. Being unsuccessful, he went on to Bilston. There, with the savings accumulated during ten years, he started a blast furnace. A workman would not imagine he could do that now. John Wilkinson was not the first to use coal instead of charcoal in smelting. Lord Dudley preceded him in that, but the process did not come into use until Wilkinson set the example, after having spent four years in experiments.

MR. HAIGH said the Paper should be of particular interest to the younger members, and it suggested several interesting reflections. Comparing John Wilkinson's achievements in gun-making with what was done in the recent war, one realised that the developments had been such as Wilkinson himself could not foresee, and even to-day men who were doing what appeared to be small things could not be sure that they would not have some part in bringing about great changes in the cast-iron industry or some other industry. The iron bridge which had been mentioned was a fine

example of what could be done with that material. So also was another cast-iron bridge he had seen. One wondered why the producers had not been sufficiently enterprising to make more extensive use of it for such purposes. The same lack of enterprise was seen in other directions. He could remember when it was the custom to use cast-iron beams in the cotton mills in the Oldham district, but in many places they had been replaced by steel.

Mr. W. H. Sherburn said he had come to the conclusion that it was very difficult to say who was the first in any field of invention; the precise origin of most inventions was disputed. He knew no better example than the case of James Watt, whose name was inseparably associated with the steam engine. He was very sensitive and not strong of body, and unless at several crises in his life he had found helpers to back him up and push his invention forward, he would have given up the struggle. Having got the idea into his mind, his difficulty was to get the engine built, and in that he was assisted greatly by Dr. Roebuck, the originator of the Carron ironworks. When Dr. Roebuck could give no further help, Boulton came in, a capitalist of the best sort, because he had a broad mind and a keen judgment. He saw there was something in Watt's idea, and he helped a great deal—perhaps most of all. In the partnership of Boulton & Watt, capital and labour were very well joined together. But still there were difficulties, and one was overcome when John Wilkinson discovered how to bore a cylinder fairly accurately. Later Murdoch came to Watt's assistance. Without him Watt could not have had his engines established in the Cornish mines against the opposition of the miners. It was a good illustration how men were dependent upon one another, and it offered encouragement to those who had no expectation of achieving fame or being recorded as having accomplished something great. So long as they did their own particular job well, it would have its effect, and none could foresee how important that might ultimately be.

Mr. Makemson said, in preparing a Paper he gave before the Burnley section about twelve months ago, he had occasion to seek information regarding John Wilkinson, and was assisted by Mr. Primrose. The conclusion he came to was that the Wilkinsons were a remarkable family. Isaac, the father, came from Wales, somewhere about Wrexham way, and he was of an inventive frame of mind, but lacked the business qualities which made his son successful. It was said that he took out the patent for the box iron, and other patents for making cylinders, pipes, and tubes by dry-sand moulding methods, very similar to methods now in use. John's success was largely due to his ability to make use of other people's inventions, but he was also endowed with sound practical common sense, keen judgment, and considerable foresight. He turned to account the new ideas which were current, and could appreciate the value and importance of the inventions which came under his notice. Credit had been given to him for substituting coke for charcoal in the smelting of iron, but the process he used was largely an adaptation of what Darby invented some years before. It meant a great deal to the iron industry, because from the time of Queen Elizabeth the consumption of wood as fuel was much restricted, and even after Lord Dudley's experiments, coal did not come into general use. Much more experimenting had to be done. By what he did in that way, John Wilkinson merited to be included among the men who had established the iron industry in this country on a sound basis, and it was surprising that he was so little known. However, in the National Dictionary of Biography there was an article about him, and some information could be gleaned in other quarters. His example was an inspiration, and it was very fitting that the Lancashire Branch of the Institute should commemorate him permanently by the memorial medal which had been mentioned. He was a strong man, and perhaps not over-scrupulous, but in some respects he was far ahead of many firms to-day in his relations with his workpeople. For their benefit he instituted a sort of pension scheme.

Mr. S. G. Smith said it was gratifying to hear that someone connected with the foundry trade had taught the people of the machine shop, and engineers generally, the right way to bore cylinders. But he was doubtful whether Wilkinson should be credited with the invention of dry-sand moulding. The particulars regarding certain castings going back about 3,000 years indicated that they could not have been cast in green sand.

Mr. J. Hogg said the Paper was not of the usual kind, and it had told him a good deal that he had not previously known about a Lancashire ironmaster, whose connection with Bilston was interesting. That district had many monuments of the industry in the shape of slag heaps. Its inhabitants seemed to understand how to make steel rails, and perhaps the Council would see there was a Paper on that subject during the next session. Another question had been raised about the apparent lack of enterprise among producers of cast iron. He wondered whether it was possible to make such houses bolted together.

The Chairman said that recently he had been in conversation with a gentleman who was convinced that houses constructed of cast iron and sprayed with concrete would be very suitable for people to reside in. There were quite a number of uses to which cast iron could be put, which had not been developed because producers were not enterprising.

A vote of thanks was accorded to Mr. J. P. Bedson for his Paper.

NEWCASTLE BRANCH (JUNIOR SECTION).

At the Annual General Meeting on Saturday, October 18, Mr. E. J. Rang, B.Sc., was elected President of the Junior Section in succession to Mr. H. F. Clements. Mr. J. E. O. Little was appointed Senior Vice-President and Mr. L. B. Chapman, Junior Vice-President, whilst Messrs. C. Dodds and L. Liddell were elected Members of Council.

Before delivering his presidential address, Mr. Rang thanked the members for the honour they had done him.

He then pointed out that one of the chief reasons for the formation of the Junior Section was to encourage the younger members of the Institute to take part in the discussions at the meetings.

He thought that the question of membership was a very important one and that it was up to the Junior Section to make its meetings of such interest and value as to attract every foundry apprentice on Tyneside. He hoped that, before his term of office had expired, they would have twice as many members as at present. An excellent programme of meetings had been arranged for the session, and also a good deal of attention had been given to the social side. He hoped, therefore, that they would have the support of every member and that they would not only come themselves, but that they would bring their friends with them.

The Junior Section particularly wanted papers of a practical nature, and, above all, they wanted good discussions, as it is frequently the case that more is learnt from the discussion than from the paper.

On several occasions during the last session 75 per cent. of those present had taken part in the discussion and it was for the members to see that this record was upheld.

Before the meeting was closed, a hearty vote of thanks was accorded to the retiring President, Mr. H. F. Clements, for his valuable services as Chairman.

Interim B.S. Specification for Cast-Iron Piston-Ring Pots for Automobiles.—This specification, which has just been issued by the British Engineering Standards Association, covers the quality of the cast-iron pots used in the manufacture of piston rings. Limits for the chemical composition of both sand and chill-castings are included, together with the requirements for tensile and elasticity tests for rings cut from the pots selected from the day's cast. The specification includes a list of the automobile standards now available. Copies of the specification (No. 5,004-1924) may be obtained from the B.E.S.A. Publication Dept., 28, Victoria Street, London, S.W.1. Price 1s. 2d., post free.

Testing Iron to Control the Properties of Castings.*

By G. W. Gilderman, Misawaka, Ind.

Perhaps in no other branch of industry does the human element play so prominent a part as in the foundry, and this element must be taken in constant consideration while drawing conclusions from any test or from any series of tests. Tests of metal are made in the foundry for two reasons: First, for the benefit of the customer to assure him that the castings are poured from metal that conforms to definite specifications; second, for the benefit of the foundryman himself to keep a check on his practice. Any attempt to provide a suitable test that will cover the varied lines of castings manufactured by foundries throughout the country presents a rather difficult problem. Foundrymen in general select their pig-iron on a chemical analysis basis, but they demand something further in the form of physical tests to determine the strength, hardness, grain, shrinkage and other properties of the casting.

Careful daily comparison of chemical and physical tests will be found of great assistance when the foundryman is confronted with difficult specifications. Intelligent consideration must be given to the difference in size and shape of the test piece compared with the proposed casting. Up to the present no one test or series of tests has been developed to indicate the exact condition of the casting from the standpoint either of its chemical or physical properties. Each test has a definite value, but additions or deductions must be made to the result to indicate what may be expected in the casting poured from the same iron.

Factors that Tend to Make Test Bars Unreliable.

Among the many factors that tend to make test bars unreliable, probably the most important is the difficulty experienced in attempting to control the cupola mixtures and the manner in which they are placed in the cupola. Many things happen in the cupola that are not listed on the programme. One of the most common sources of trouble may be traced to a variation in the size of the scrap iron. The men making the charges, as a rule, are somewhat unreliable. At times all the light scrap will be placed in one charge with several pieces of heavy scrap in another. The heavy scrap tends to settle in the coke bed, and at times two or three charges will melt down before the heavy pieces are entirely fluid. On the other hand, the light scrap sometimes will melt before the pig-iron in the same charge, with the result that one tap will contain too light a percentage of scrap and another, perhaps immediately following, will have an excess.

Variation in Casting Qualities.

An example of this was encountered recently. A floor of 12 pulleys was poured during the same heat. Ten of these pulleys were sound, while on two the arms had pulled apart. An analysis of one of the perfect pulleys showed the following: Silicon 2.18 per cent., and sulphur 0.085 per cent. One of the defective pulleys on analysis showed silicon 1.85 per cent. and sulphur 0.113 per cent. The excess of sulphur and deficiency in silicon will be noted in the defective sample. A test bar was taken from the second tap, one from the middle of the heat and the third from the last of the heat. All three bars proved satisfactory and all showed silicon in the vicinity of 2.15 per cent. A chill test taken from the middle of the heat, poured from medium hot iron, showed a very fine white line across the bottom of the bar. However, the test of the bar compared very favourably with the average from the daily practice in this foundry.

It will seem from above that the two defective pulleys must have been cast from clear scrap, and as none of the test pieces happened to be taken from this particular ladle, had this iron been poured into some casting of a more rigid design, this hardness might not have been discovered until the casting was machined. Yet four tests taken from different parts of this heat were entirely satisfactory.

A round plate casting of the following dimensions, 8¾ in. dia., 3 in. thick, with a solid hub on one side, 3½ in. in dia. and 6⅜ in. long, was cast from the same ladle with a 1¼-in. test bar. Both the casting and test bar were moulded in green sand, and, after pouring, were allowed to remain in the mould until cold. The hub projecting from the casting then was broken off and drillings taken from the centre of the plate analysed as follows:—Silicon, 1.91; manganese, 0.76; phosphorus, 0.530; sulphur, 0.088; and combined carbon, 0.47.

Drillings taken from the centre of the test bar showed practically the same analysis with the exception of combined carbon, which was 54. A transverse breaking test of this bar gave 2,640 pounds. It would be unsafe to figure the casting on the same basis as the test bar. While the outer shell of the casting in all probability would compare favourably with the test bar in strength, the inner section would be weaker, due to the difference in cooling and the consequent difference in the percentage of combined carbon.

Chill Tests Criticised.

In the author's opinion a chill test is not always reliable. In one instance two bars were cast in iron moulds 5 in. thick, 6 in. wide, and 16½ in. long. The bars were 12½ in. long and with an average of 2 in. square cross section. It will be seen that the chill provided 3 in. of metal beneath the bar and 2 in. entirely surrounding it, with the exception of the top, which was open. The first bar was poured at a very low temperature, and showed a white line across the bottom 3/64 in. The sides showed no white whatsoever with the exception of the bottom corners, where the chill was about ⅛ in. deep. Drillings taken from the top of this bar showed an analysis of silicon 1.84, manganese 0.72, phosphorus 0.531, sulphur 0.078, and combined carbon 0.47 per cent.

This bar showed no gradual tapering off from white to grey, but a sharp demarcation existed between the chilled portion and the ordinary grey section.

The second bar was poured at a very high temperature and showed a white line across the foot 5/64 in. deep. This line also extended up the sides of the bar for about 5/8 in. The chill at the lower corner was about ¼ in. deep. This bar showed a gradual tapering from white to grey, and drillings taken in the same manner and from approximately the same location in the bar gave an analysis of silicon 1.82, manganese 0.56, phosphorus 0.497, sulphur 0.091, and combined carbon 0.60 per cent.

It will be noted that the second bar showed a much deeper chill than the first. The silicon, being practically the same, could not have caused this variation. While the manganese is higher in the first than in the second bar, the sulphur is reversed, and is higher in the second than in the first bar. Judging from the analysis, it is the opinion of the writer that had these two bars been poured of iron of the same temperature they would have shown approximately the same chilled conditions.

Test Bars and the Properties of Iron in Castings.

This furnishes an indication of the unreliability of common tests unless all of the variations encountered are carefully noted. It also supports the contention that any test made in this manner is not strictly a measure of the properties of the casting, but rather a test of the iron when it is poured into the casting. Foundrymen often develop some simple test that will give information adaptable to his one peculiar line of work. The writer considers the best guide for general use is the 1¼-in. round test bar poured in a dry-sand mould. As it is rather difficult to obtain a true tensile test, the transverse generally is used, placing the bar on supports 12 in. apart. The load is applied at the centre at a speed to pro-

* A Paper read before the Milwaukee Meeting of the American Foundrymen's Association. The author is connected with the Dodge Manufacturing Corporation.

duce 0.10 in. deflection in about 30 seconds. Drillings may be taken from the broken bar for a comparison of chemical analysis, and for a consideration of the effect of the chemical analysis upon grain structure, strength and other physical characteristics. A careful study of the grain structure compared with the analysis at times will assist in eliminating segregation or shrinkage. Further, the bar may be placed in the lathe and the end turned to determine the degree of hardness and resistance to machining.

Precautions Needed in Making Test Bars.

In making the mould for the 1¼-in. test bar, great care should be exercised in ramming, in order that the bars may be as near the same diameter as possible each day. Perhaps the safest plan is to make the mould on a jolt rammer. Decide upon the number of jolts necessary to secure the proper density, and make this a daily practice. Even with this precaution there will be at times considerable variation in the breaking point of the different bars. Table I is part of a foundry record where daily tests are made, and does not include any bars which contain a flaw of any kind. Bar No. 1 was cast at the beginning of the heat, bar No. 2 at the middle of the heat, and bar No. 3 at the last of the heat.

Table I.

Heat No.	Chemical Analysis. Si.	S.	P.	Mn.	Bar Number. 1	2	3
					Transverse strength.		
1*	1.61	0.095	0.44	0.70	3,660	3,590	3,640
2	1.90	0.090	0.46	0.60	3,050	2,940	2,925
3	2.10	0.089	0.58	0.63	2,600	2,795	2,764
4	2.16	0.087	0.60	0.71	2,415	2,700	2,740
5	2.25	0.081	0.57	0.67	2,540	2,440	2,800
6	2.42	0.082	0.61	0.61	2,460	2,340	2,310

*20 per cent. steel.

Hardness Testing.

As a test for hardness the scleroscope and Brinell machines are both used. The Brinell test is more easy to read, and consequently more accurate for practical use. Generally speaking, where hardness is required the casting is subjected to great wear, and a certain degree of hardness is specified to ensure a certain amount of wear. When this is true it would seem the Brinell machine is to be preferred over the scleroscope, for the reason that with the Brinell a certain pressure displaces a certain amount of metal. This is practically what happens when the casting is put into use.

The Brinell test is used to good advantage on castings for internal-combustion engines in determining the degree of hardness of cylinders, pistons, piston rings, and other parts subject to wear. Of course, it also may be used to advantage on any casting where the degree of hardness is confined to narrow limits. Best results are obtained by taking two or three castings from each hundred after they have been machined and applying the test directly.

Making Templates.

By J. E.

Many factors have to be taken into consideration when making templates. Some pattern-shops use one thickness of timber irrespective of the size of a job or the purpose for which a template is required. As a matter of fact the ideal template for one purpose may be almost useless for another. Pipes are often made from templates of very thin wood, which are not reliable. When boards are placed against the flanges, on the pattern-shop floor, the construction yields and the pattern, when made, is not satisfactory. Additional machining may have to be left, and the flanges also thickened behind practices which may be advisable with large pipes, even when rigid templates are used, but which should not generally be adopted for small work. Unless when templates are used simply to obtain a straight length—as length rods—they should be of timber at least ¾ in. thick. Plywood is occasionally used for templates, but it is not satisfactory; it must be battened, screws do not penetrate it readily, and it is too thin. The only recommendation of plywood for pattern-making is that it does not split.

Templates may be divided into two kinds—those that are only to be used as such, and those that will be converted into patterns. An important advantage of not using a template for the actual pattern-making is that it can subsequently be used, in the case of pipes and valves that form closing pieces, in a long range, as a machining template for bolt holes.

Then there are occasions when pipes are slung up temporarily in order to let the pattern-maker make a closing piece; when they are taken down, and finally re-erected, flange angles may have altered and difficulty may be experienced in getting the closing piece into position. If, on such occasions, the pattern-maker has the template intact, it is a witness that the fault lies, not with him, but with the fitters. It is quite common for a series of three or four pipes, vertical and horizontal, to be required in an engine room for which no drawing is supplied, and it is always wise to make patterns for all but one piece, which should not be made until the other pipes are finally erected. Closing pieces like these are sometimes made three or four feet long, but a short pattern and casting is more quickly produced and is more easily handled. The thickness of the metal is usually left for the pattern-maker to decide.

In some shops, especially in marine shops, a large proportion of work has to be tried to place. A blue print is supplied to the pattern-maker, which gives full particulars, but the instruction is printed on it that before being sent to the foundry it must be tried to place. Some pattern-makers, in such cases, will complete the pattern, and they may then find it necessary to dismantle it. Not only distances between flanges may be altered but the actual shape also. If it is decided not to construct a template the pattern should be fitted to place as a skeleton with centre plates, and the flanges supported with brackets. The shape can then be modified, the flanges extended to allow for contraction and machining, and the construction completed. With regard to machining allowances, it is always advisable to leave liberal allowance. If the bolt holes are to be cored instead of bored, a paper template may be placed against the flanges, against which the new piece will fit, the holes marked with pencil, and a line also transferred from the top of the flanges. The centre of the holes on the new casting can then easily be marked, and the top guide lines which have been transferred from the template ensure against error. It is a good practice, with all closing pieces, to cast a raised guide line on the flanges; a corresponding line can be made on the existing pipes with a cold chisel, or a few punch marks, and the fitter does not require to try the pipe in different positions until he finds the correct one.

There are occasions when a template cannot be other than flimsy. Shipyard templates are often of this kind, because the pattern itself is fragile. A common job in a shipyard pattern-shop are T or L section pieces or channel pieces. They may be several feet long, of narrow width, and ¼ in. metal. The template may be a length rod with necessary particulars marked on it. Carpenters' templates for coppersmiths are often of very thin wood, but it has to be remembered that copper pipes will accommodate themselves if they are not quite accurate, better than iron pipes will do. Carpenter's templates, like carpenters' patterns, are not very often satisfactory, although in some shipbuilding yards they do much template work, and occasionally hawser pipe patterns are made by them.

A questionable economy sometimes practised is to make templates of spruce instead of yellow pine. Such templates are seldom satisfactory, and, if they have to be used as guides for the machinist, are unreliable. Templates should invariably be made of good timber and with care.

Kenjiho Works in Korea.—The Kenjiho Iron & Steel Works in Korea, under the management of the Mitsubishi Company, are producing some 10,000 tons of pig-iron per annum in two blast furnaces. Owing to shortage of ore, new supplies of ore will have to be imported. The Company owns steelworks capable of producing plates and sections to a total of about 50,000 tons a year, but this plant is now idle, pending the return of Mr. Matsuda, its superintendent, who is abroad studying steel manufacture.

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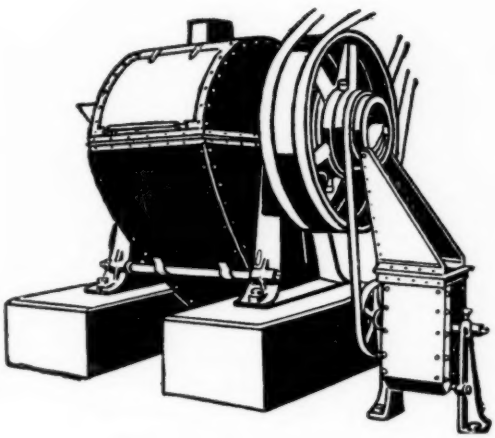

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—In the concluding week of an exciting political contest it is hardly surprising that business in the Cleveland iron trade has been temporarily in abeyance, with buyers marking time until the issue is definitely decided. Nevertheless, there is certainly a better feeling on the market, and this can no doubt be ascribed to the general expectation that the country will soon be in possession of a more stable administration. It is, however, satisfactory to report that, as far as foundry iron is concerned, the current restricted output is going into consumption, and there is no accumulation of stocks, while the price is at a figure below which makers, having already discounted all recent concessions as regards raw materials, are not prepared to go. In the meantime prices remain unchanged, No. 3 G.M.B. quoting 80s. per ton, with No. 1 85s., No. 4 foundry 79s., and No. 4 forge 78s. per ton.

In the home trade the demand for hematite continues slow, and at present current production is not being absorbed, with considerable accumulation of stocks in hand. Makers, however, are disinclined to cut prices further, and 87s. per ton is now the minimum figure for East Coast numbers, with an additional 6d. per ton for No. 1 quality. On the North-West Coast business is also on a hand-to-mouth basis, Bessemer mixed numbers being quoted at 100s. per ton delivered at Glasgow, 102s. 6d. per ton at Sheffield, and 106s. per ton at Birmingham.

LANCASHIRE.—Buyers of foundry iron in this area are still limiting their operations to actual immediate requirements, forward business at the moment being practically non-existent, even on the basis of 90s. per ton delivered equal Manchester. At present the lowest figure accepted for No. 3 foundry iron, delivered local, has been 88s. per ton, and that was not Derbyshire. The latter makers, for the most part, keep to a basis of 82s. 6d., on trucks, equal to about 90s., delivered; but there have been one or two offers at 1s., or perhaps 1s. 6d., less. There has been no material change in the prices for Scotch pig-iron here. For the best brands of No. 3 the theoretical price is still based on 90s. at the furnaces, and, if delivered by rail, would amount to 106s. 6d. in Manchester; but for all this quality iron has been sold here at 105s., and even at 104s., delivered.

THE MIDLANDS.—For the obvious reasons stated above, there is very little business passing this week in the Black Country districts, buyers holding off the market in the hope of obtaining reduced prices for the No. 3 quality iron, for which there is only a limited demand. Current prices may be quoted as follow:—Derbyshire No. 3 foundry, 80s. to 82s. 6d.; Staffordshire No. 3 foundry, 95s.; Northants No. 3 foundry, 72s. 6d. to 78s.

SCOTLAND.—There has been just a shade more inquiry in the market of late, and consumers are more inclined to take an interest in making forward purchases. Several deals have been put through for delivery into next year. Prices are still easy, however, and there is very keen competition for any business appearing. Merchants seem to be prepared to cut the makers' current prices in order to secure the business. The nominal quotation for No. 3 remains at 90s., but for actual business down to 88s. has been taken.

Finished Iron.

Activity in the manufacturing sections of the iron industry is, as usual of late, chiefly confined to the mills turning out marked bars, for which there is a moderately good inquiry. These conditions are, however, entirely reversed in the case of the works manufacturing crown and the cheaper quality irons. Soft steel bars can be obtained at 55s. per ton less than crown iron, and where possible the former is certain to be utilised. Apart from this consideration, there is so much competition from abroad, where iron is being offered at £7 5s. per ton delivered against the local figure of £11 15s. per ton for nut and bolt quality. Further, the consumers of this material are very short of work, and desirable lines are few. The whole of the districts have now reduced prices of crown iron by 10s., making Lancashire bars £12 10s., Yorkshire £13, Cleveland £12, and Scotch £12. Staffordshire crown bars are 5s. down. The Scotch sheetmakers have also reduced their prices by 10s. for the heavier gauges, up to 20s. for lighter gauges.

Steel.

In the steel market business does not improve to any extent. Although during the steelworkers' strike the buying of billets was practically suspended, the resumption of work has not, so far, helped business much, and makers of both acid and basic billets report slackness. There are plenty of Continental billets to be had, but in the main they are not very popular here, despite their comparative cheapness. Siemens acid billets are quoted around £12 10s., while basic billets are: Soft, £8; medium, £9; and hard, £9 5s. The market for ferro-manganese continues quiet and practically unchanged. The outlook in the tinplate industry is considered somewhat uncertain owing to difficulties concerning merchants' commission.

Scrap.

Conditions in the various markets for scrap material continue quiet, with faint prospects of early relief from the prevailing depression. The Lancashire foundry trade is rather short of work, and the further ease in foundry pig-iron leads consumers to expect another reduction in scrap prices. Strong holders of good cast scrap are still trying for 85s. for the best qualities, but good lots have been sold at 82s. 6d., and even 80s., and as for so long a time consumers have been accustomed to buy broken machinery iron at about 10s. less than No. 3 pig, it is natural that they should now expect to get it at something under 80s. In Scotland machinery cast-iron scrap is still retaining its price of 83s. 6d. to 85s. per ton for quality, of course suitable for foundries, and in pieces not exceeding 1 cwt. For ordinary cast-iron scrap to the same specification, 80s. per ton is quoted, and for larger material to steelworks specifications, 75s. to 77s. 6d. per ton. Old cast-iron railway chairs still remain around 83s. 6d. to 85s., and for light cast-iron scrap, for which there is a better inquiry, the light metal mixed is 62s. 6d. to 65s. per ton.

Metals.

Copper.—Movements in the standard market of late have evidenced a distinct tendency to firmer conditions, due to American and Continental influences, and the growing impression that consumption of the metal in the near future will show a steady progressive increase. Speaking generally, there is little doubt that trade is really improving, though gradually, and so soon as the users of the metal can confidently see far enough ahead to buy not only their near, but also part of their future, requirements, prices of metals will steadily improve. The electrification of railways which is contemplated, and which has actually commenced on a large scale in many countries, must ultimately create a large demand for the red metal. Current quotations:—*Cash*: Thursday, £62 17s. 6d.; Friday, £63 2s. 6d.; Monday, £63 15s.; Tuesday, £63 7s. 6d.; Wednesday, £63 10s.

Three Months: Thursday, £64; Friday, £64 5s.; Monday, £64 17s. 6d.; Tuesday, £64 10s.; Wednesday, £64 12s. 6d.

Tin.—This section of the market fully retains the buoyant and confident attitude of recent reports, with values marking a consistent upward tendency. The position of the metal is undoubtedly sound, and consumption is more than taking care of the current production. The frequent changes of feeling have been largely the result of manipulations on the part of certain professionals, apart from the intermittent character of the American demand. The home demand has been moderately active, while better purchases were reported for the Continent. Current quotations:—*Cash*: Thursday, £253 10s.; Friday, £256 2s. 6d.; Monday, £256 5s.; Tuesday, £253 2s. 6d.; Wednesday, £258.

Three Months: Thursday, £255 10s.; Friday, £257 15s.; Monday, £258; Tuesday, £255; Wednes- £259 10s.

Spelter.—Operations in this metal have been on a limited scale, but with values inclining to firmness. The Continental manufacturers, although still holding for high prices, appear lately more inclined to meet the market. Meantime further purchases have been made from America. There is room for improvement in the current demand from consumers, particularly on the part of the galvanised sheet trade, which has slowed down considerably. Current quotations:—*Ordinary*: Thursday, £33 18s. 9d.; Friday, £34 1s. 3d.; Monday, £34 7s. 6d.; Tuesday, £34 5s.; Wednesday, £34 5s.

Lead.—The market for soft foreign pig continues quiet. The demand from home consumers has been only moderate, and cable makers, although busy, are said to be working at less pressure than was the case a few weeks back. Current quotations:—*Soft foreign (prompt)*: Thursday, £36 17s. 6d.; Friday, £37 15s.; Monday, £38 5s.; Tuesday, £38 2s. 6d.; Wednesday, £37 5s.